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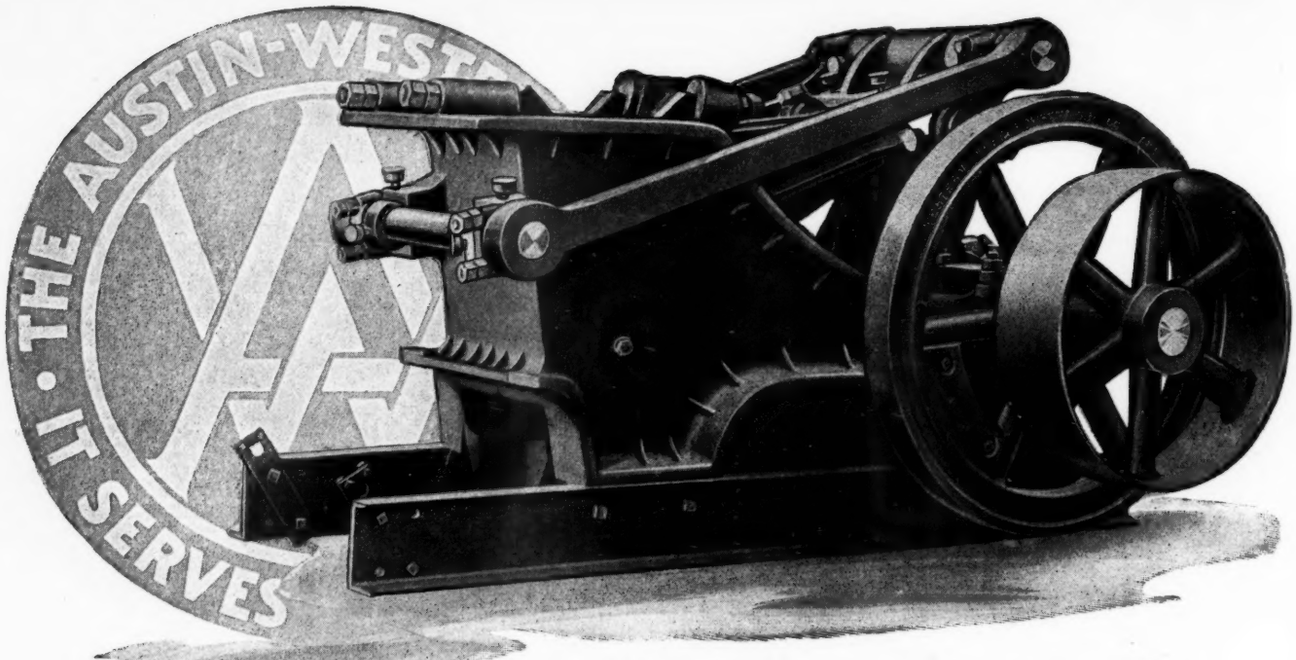

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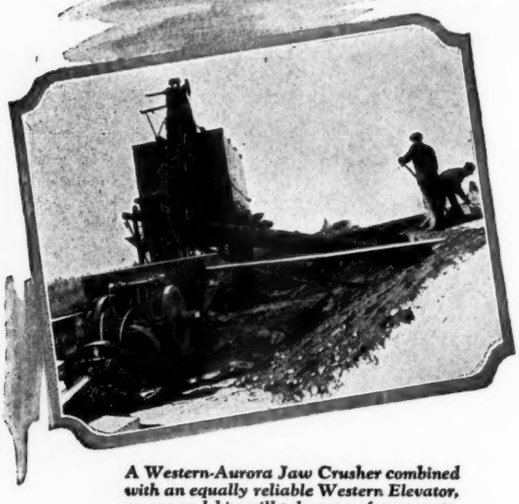

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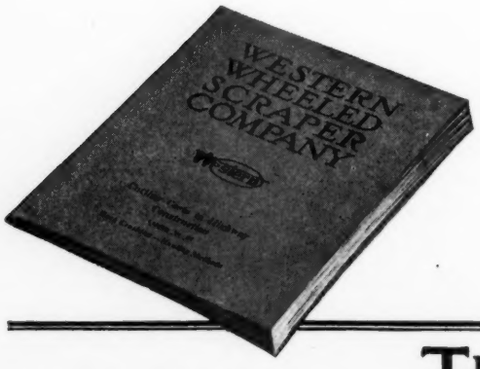

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Snow Removal on Pennsylvania Highways

Desirability from a financial standpoint. Equipment and organization. Method of operation. Amount of work done last winter and cost per mile and per inch-mile. Effect of location, snow fences and hedges.

By W. A. Van Duzer *

Snow removal is a problem which is becoming more and more general and more and more pressing.

Each year the battle between snow and highways engages the attention of a greater number of people, including road users and road officials.

The constantly expanding mileage of improved roads, the steadily growing multitude of motor vehicles and the accompanying and increasing tendency of the public to depend upon highway transportation each year, subjects hugely enhanced investment and industry to the threat of winter paralysis.

Furthermore, with the increased traffic, the damage to the road and the consequent cost of maintenance become excessive if drifts force traffic from the surface to the side of the road or if an accumulation of snow is permitted to melt on the road and weaken the foundation. The economics of snow removal touch upon traffic and maintenance.

*Deputy Engineering Executive, Pennsylvania Department of Highways.

The present article describes snow removal in Pennsylvania, but deals with conditions and factors in such a way as to indicate the analogy to any other state in which the reader may be more particularly interested.

The season, total fall and drifting of snow vary somewhat over the State, but in general it may be said that if no combative measures were used, snow would make the highways of Pennsylvania impassable to motor vehicles for about thirty days a year.

The state highway system comprises 10,779 miles, of which some 4,250 miles were kept free from snow last winter. The 4,250 miles represents an investment of approximately two hundred million dollars and carries approximately 60% of all of the highway transportation in the State, outside of cities.

The investment value of the primary system then covers 40% of the value of the motor vehicles of the State. There are about one million and a half of these, with a total valuation of approximately a

TYPICAL VIEW OF PENNSYLVANIA ROAD IN SNOW SEASON.

billion and a half dollars, of which the 40% accountable to the primary system would be six hundred million dollars, making the total value represented by the primary system eight hundred million dollars. Figuring this investment at 6% annuallly, one-month would be equivalent to one-half of one per cent or four million, but traffic counts show that the winter daily average is only 70% of the annual daily average of traffic, and in the same way the snow season traffic would be only about 70% of the winter average. Therefore, the normal value of one-half month of the primary system during snow weather would be about two million dollars, and from the standpoint of investment only, the two million dollars represent the value of snow removal.

From a standpoint of travel, the annual daily average on Pennsylvania primary roads is 424,347 vehicles, winter daily average about 300,000 and approximately 210,000 per day during such time as roads might be blocked with snow. Thirty days travel would be about six and a half million vehicles and comparing this latter figure against the two million dollar investment value of snow removal charge would be about thirty cents per vehicle, or, since the average winter trip on the principal roads in Pennsylvania is about 30 miles, one cent per car mile.

In another way and more directly, the state is financially interested in snow removal. The high costs of spring maintenance can be very greatly affected by snow. If drifts are left to be worn out by weather and traffic they will remain an obstruction long after travel has forced a way through the road. The wheel tracks will naturally follow the line of least resistance, and will weave from edge to edge of road, and show no preference for the road surface. If the road is heavily traveled, there will be two pairs of wheel tracks, otherwise one pair. In any event the wheel tracks will run along the edge of the surface at intervals and at intervals will take to the shoulder, and until the snow has practically disappeared travel will track and favor the ruts. While the ground remains frozen this is not serious, but when the snow melts and softens the ground the ruts become ruinous to shoulders and seriously damage the edges of flexible types.

With snow impediment and traffic of 300 or more vehicles per day, certain types of roads may in one week of thawing weather suffer damage greater than the cost of an entire winter of snow removal.

PROGRAM

In the winter of 1923-24, 2,902 miles of road were on the snow removal program. In 1924-25 the mileage was increased to 4,252, covering nearly all of the primary system and including those of the secondary roads carrying the heaviest traffic. Plans for 1925-26 have not been completed but will be more extensive.

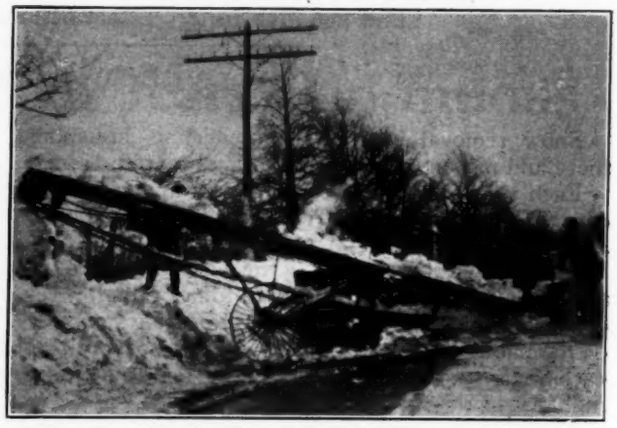
EQUIPMENT

In the state there are 424 motor trucks, 225 of them being four-wheel traction type, and 120 ten-ton caterpillar tractors, the trucks equipped with "bar" or "mold board" type plows and the tractors with "V" type.

This provides approximately one plow to eight miles of road.

The trucks are considered adequate for handling ordinary snow with drifts to 24 inches.

Plows are mounted ahead of the chassis rather than being carried under or dragged and so for two reasons four-wheel traction trucks are preferred; first, the rooting of the plow has a tendency to lift the rear end and lessen the traction of the rear wheels; and second, the side shoving of the plow, if not partly offset by the driving grip of the front wheels, has a long leverage to the rear wheels to cause skidding. For sections of road where greater than 24-inch depth is regularly encountered, tractors are provided.



USE OF LOADER WITH HAND SHOVELING

Operators are subject to call and continuous duty.

For emergency there are available a number of maintenance or construction machines such as blade graders and machine loaders that are very serviceable under special conditions.

ORGANIZATION

The work of snow removal is handled as maintenance. The state is divided into four divisions, north-west, north-east, south-west and south-east.

TRUCK PLOW.

TRACTOR PLOW.

each in charge of a division engineer. Within the divisions there are engineering districts, fifteen in all, each in charge of a district engineer subordinate to the division engineer, and within the engineering districts there are maintenance districts, fifty-two in all, each in charge of a superintendent subordinate to the district engineer. The superintendents have centrally located storage sheds which are kept heated through the winter and in which the snow removal equipment is housed.

OPERATION

The superintendent by arrangement with the United States Weather Bureau receives from the nearest station advance warning of approaching storms and notifies his men, equipment is made ready, and as soon as the falling snow reaches a depth of two inches work is started and is continued until the danger of blockade is over and the road clear for two-way traffic.

In case of thawing weather, side ditches and culverts are cleared and shoulder drains opened where snow stands between road and ditch.

In case of breakdown of equipment, repairs are rushed from the superintendent's repair shop.

The superintendent keeps in close touch with his outfits. He wires the Harrisburg office when any road becomes blocked and wires again as soon as it is opened to one-way and to two-way traffic.

As far as possible the plows are permitted to handle the work, and the main considerations are to start the equipment at the right time and keep it moving; but if the drifting gets out of control of the machines, or if ditches or culverts are to be opened, the superintendent puts out foremen and hand shoveller to get the work done.

After the program roads are clear, such other state highways as are blocked are opened as far as possible by breaking drifts.

On the program roads it is the practice to clear to within two inches of the surface and the two inches of snow soon wears off. On the other roads, though, the drifts are merely broken through to make them passable to motor vehicles, the principle being that the primary roads are maintained for through traffic, which is almost entirely motor vehicles, while the chief traffic on most of the secondary roads is local and during the winter a large percentage of this is on sled runners.

During the winter of 1924-25 the total cost of snow removal was about 10% of general maintenance costs. Of this amount, 20% was expended in breaking drifts on roads not on the program and in miscellaneous charges.

Snow Removal Cost, Winter of 1924-25

Item	DIVISION N.W.	N.E.	S.W.	S.E.	State Total
No. of miles	942.97	963.26	987.18	1358.26	4251.67
No. of inch-miles	63954.59	55173.29	35478.97	75030.66	229637.51
Average cost per mile	$60.55	$51.30	$27.24	$144.48	$77.53
Aver. cost per inch-mile	.89	.90	.76	2.62	1.44

The measure of performance used is the "road mile," meaning mile of road kept open through the season and "inch-mile" meaning snow removed one mile length of road, eighteen feet width, one inch depth. The total number of inch-miles in round numbers is two hundred and thirty thousand and is equivalent to about sixty-nine million cubic yards or about five and three quarter millions of tons.

The costs average $77.52 per road mile for the season, or $1.44 per inch mile, or one-half cent per cubic yard, or six cents per ton. In the S. E. division there was a great deal more hand shovelling than in the other divisions, due to the fact that a great deal of snow had to be loaded to wagons and hauled away from state highways that are built up to such an extent that they are practically city streets.

HEAVY DRIFT OPENED BY HAND SHOVELING.

REPORTS

In considering the details of snow removal statistics it must be remembered that one of the principal items, namely quantities of snow moved, is secured from the reports of the men on the work and these men have been doing hard work, generally in bad weather, always with the urge of haste and with little

opportunity for reflection of progress or accomplishment. Most of the work is done by the plows, day and night, with thirty-six or forty-eight hours continuous operation not unusual. Such discrepancies as may be found in the details are due to these conditions and are almost unavoidable.

COMMENTS

The great difficulty and the heavy expense in snow removal is induced by topographic conditions.

In many cases drifting could be avoided by relocation, but generally the cost of moving the road would be too great to be justified by consideration of snow and a possible remedy then is the artificial alteration of the topography, sometimes by moving obstructions so as to eliminate the drifts, but more generally by placing snow fence to throw the drifts where they will not be objectionable. The general rule is to place the fence between the road and the prevailing or threatening wind, the distance from the edge of the road to the fence being ten times the height of the fence. It is sometimes found advisable to place the protection along both sides of the road.

An approximate rule found to be practical in planning snow fence is that the fence eliminates about seventy-five per cent of the cost of hand shovelling. As to the type of fence, it is probable that the picket and wire will be more economical in the long run than the so-called "railroad portable fence." The planting of hedges or thickets to serve as permanent wind breaks is undoubtedly desirable from a standpoint of road maintenance, but the owners of the road side property almost invariably object to such hedges as would be useful.

Wyoming Snow Handling

According to Z. E. Sevison, State Highway Engineer of Wyoming, the Highway Department of that State "does not carry on any snow removal program except in isolated cases where traffic conditions may justify it. Funds available for construction and maintenance are so limited that it has not been possible to carry out a policy of snow removal up to the present time."

Investigating Culvert Pipe

An investigation of culvert pipe is being started by the Highway Research Board under the direction of R. W. Crum, engineer of materials and tests of the Iowa State Highway Commission. The object of this investigation is to correlate the various tests and experiments on pipes, loads and stresses; to set up a standard of comparison of the life of different kinds and classes of culvert pipe; and to determine the most probable conditions of service for which standards should be designed.

Snow Handling on Minnesota Highways

Snowdrift prevention rather than snow removal the policy of the department, but 350 miles are plowed.

By W. F. Rosenwald *

The most important question with regard to the snow removal program in this state is the justification of expending public funds for this purpose.

Up to the present time, this department, through its maintenance organization, has not attempted any general snow removing program over the trunk highway system, although certain roads, on account of the heavy traffic, have been deemed necessary to include in a snow removal campaign throughout the winter months.

Our general policy has been that snow drift prevention, by use of snow fence properly erected, was more effective and desirable, considering its cost, than actual snow removal operations. At the present time this department maintains and erects each fall approximately 200 miles of picket fencing at various points along the highways where drifts most naturally occur, the fence barrier throwing the natural tendency to drift back off the highway. This practice has permitted the use of a large portion of our trunk highway mileage during the winter season on account of the fact that the highways heretofore impassable were probably so on account of two or three heavy drifts over a comparatively long mileage of road.

Our actual snow removal program has embraced approximately 200 miles of arterial highways in the vicinity of the Twin Cities and about 150 miles of highways northwest from Duluth along the shore of Lake Superior, to afford means of ingress to this territory which has no railroad facilities or lake service during the winter months.

This department has experimented with a number of types of snow removal apparatus, both in the rotary and fixed blade units, and for general use finds the old type "V" plow to be the most generally effective.

During the coming winter we plan to use eleven high speed snow plow units, which consist of two F. W. D. trucks running tandem with a "V" plow mounted on the forward truck

*Maintenance engineer, Minnesota Department of Highways.

and a wing plow widener on the right side of the rear truck. This combination, on account of its momentum and high speed, has served most effeciently in the removal of snow, particularly if operations are carried on during and immediately after the snow fall. We also will have in operation about five ten-ton tractor units equipped with "V" plows and wideners, which will be used to supplement the truck units, particularly over roads on which the snow has become packed, or where the highway has not been paved and the high speed units cannot operate except at a hazard.

In addition to the highways being kept open by the State, the various bus and transportation companies have co-operated in keeping certain of the most important routes open for winter traffic but, as stated above, very little rural snow removal is attempted on account of its high cost, and also because it complicates the farm transportation problem since sleighs must be used in certain localities and cannot be used over the roads which have been plowed out.

The elimination and avoidance of natural snow barriers is being taken into consideration in the relocation and alignment surveys in laying out our present construction projects, which will materially assist in handling the snow situation.

With regard to the cost of snow removal work, we have found it practically impossible to arrive at any sort of a cost per mile or cost per foot of snow removal, on account of the widely varying depths of fall and drift conditions. Owing to the mild weather conditions during the winter of 1924-1925, the extent of snow removal operations was not sufficient to arrive at any representative cost data.

In conclusion, we might state that the situation has practically resolved itself into a matter of keeping the paved highways open by use of snow removal units, as described above, during the winter months, and taking whatever steps possible to avoid occurrence of drift blockades on rural highways, leaving them to be packed so that they will be travelable by either wheeled vehicles or sleighs during the snow period.

Sanitation in Birmingham's Unsewered Areas

More than five thousand houses are more than two hundred feet from the nearest sewer. Ordinance adopted this year requires installation for such houses of earth pit toilets and septic tanks.

By W. A. Hardenbergh*

Within the 52 square miles comprising the corporate limits of the city of Birmingham are approximately 35,000 houses, of which about 16 per cent, or 5,600, are without sewer connections. Yet every house within reach of a sewer is connected to it.

Why there are so many houses that are denied the benefits and conveniences of sewers, what the city is doing to serve these unsewered districts, and how health is being protected in them may be of interest to the many other cities that are faced with the same problem. While this problem is perhaps more acute in the South, where civic growth has been so rapid in the last two decades and where most cities, large or small, have from 15 to 40 per cent of their homes unsewered, it is also a problem, even if not to the same extent, throughout the entire country.

Many reasons are to be found for the existence of the unsewered districts of Birmingham. Perhaps the fundamental one is that the present sewer system is a combination, or a hodgepodge, made up of the entirely unrelated sewer systems of the dozen or more towns and real estate developments that were combined in 1910 to form the city of Birmingham. The sewer systems of these towns and developments were not, of course, laid out with any idea of forming at some later time a coordinated part of a system. As a result there are areas on the

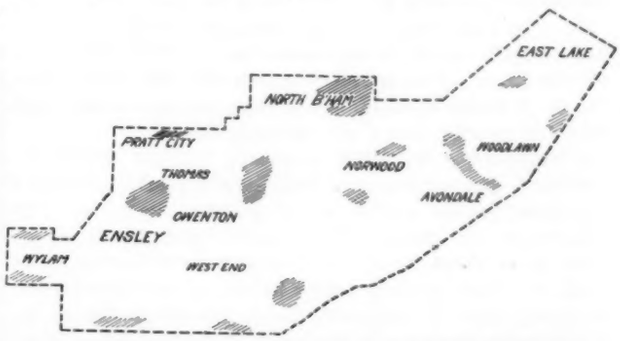
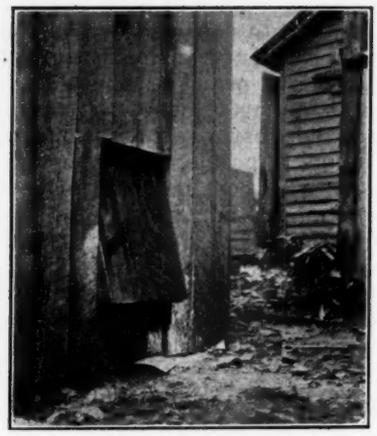


FIG. 1—OUTLINE OF BIRMINGHAM, SHOWING SOME OF THE MUNICIPALITIES AND TOWNS WHICH WERE CONSOLIDATED TO MAKE UP GREATER BIRMINGHAM. SHADED SECTIONS SHOW UNSEWERED AREAS.

*Director of rural sanitation, Jefferson County, Alabama, Board of Health.



BOX AND CAN TOILET OF THE TYPE USED IN BIRMINGHAM.

fringes of these little municipalities or between them where sewers are not available. It is impossible in many cases to reach these sections by a lateral or submain from any existing sewer because of lack of grade; while in other cases the cost would be entirely out of reason.

Many other reasons contribute to the size of the unsewered area. The trunk sewers and most of the main sewers were designed and built 25 years ago when few people foresaw the tremendous growth of the city. As a result of too little allowance for future growth, the sewers are inadequate to carry the flow of sewage. In wet weather periods, many of the manholes in the trunk sewer spout like geysers, the sewage flowing under a head. In certain parts of the city, toilets cannot be installed on the ground floor of buildings, as the sewers are generally flowing full and the toilets will not flush. It is of little use to build new laterals or to construct new submains opening up new districts when the sewers are already overloaded.

During a part of the year—mainly in the winter or wet season—the ground water level in many parts of the city is high, and the sewers, already heavily loaded with the normal flow of sewage, become surcharged by the infiltration of ground water.

There are, therefore, many good reasons why such a large area of the city is without sewers. But as a matter of fact, the proportion of unsewered homes is much smaller than in most Southern cities.

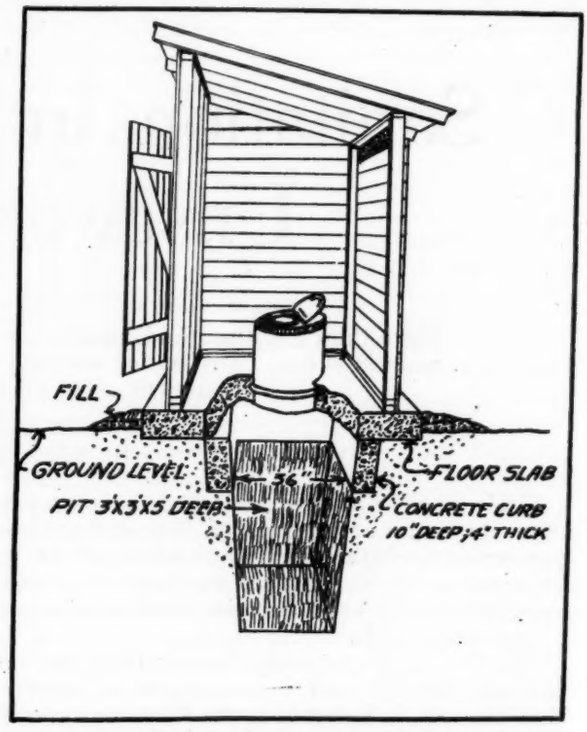
Until 1918, the laws concerning sewer connections were laxly enforced. A severe typhoid epidemic swept the city in 1916 and 1917, and, as a health measure, all houses within 200 feet of sewers were connected. Since that time the laws have been strictly enforced and there are now practically no houses that are not connected where connections are practicable.

Beginning in 1918, sanitary toilets were installed in every unsewered home in the city and in practically every home in the suburbs. The laws of the State of Alabama give to cities of the first class police and health jurisdiction over all territory within three miles of the city limits, and under this authority the zone surrounding the city was sanitated.

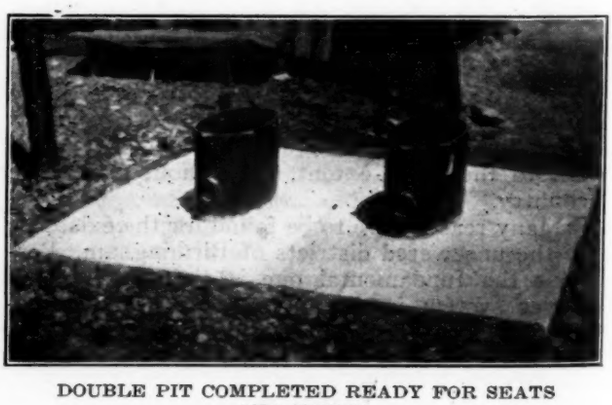
The type of toilet adopted was the so-called box and can toilet, which consists of a galvanized iron can of about 11 gallons capacity placed within a fly-tight box. At intervals of a week, the can must be emptied.

Twenty tank wagons were put into service to scavenge the 6,000 or more toilets then in use. Dumping stations were established over sewer lines, where the wagons, after collecting a load of can contents, could empty. A fee of 50 cents per month was established to pay for the cost of scavenging.

With a few changes, this system is still in use. It has done well despite the many disadvantages inherent in this type of toilet.. The typhoid rate, which in 1917 was 65 per hundred thousand, is now only 7 per hundred thousand—a reduction of nearly 90 per cent. The death rate of infants from colitis has dropped from 184 per hundred thousand in 1917 to about 40 in 1924. Of course, not all of this reduction is due to the sanitary toilets. One of the finest health organizations in existence has been carrying on intensive work in nearly every branch of health endeavor, notably in nursing and child hygiene and in milk control, and much of the reduction



SKETCH OF THE EARTH PIT TOILET.



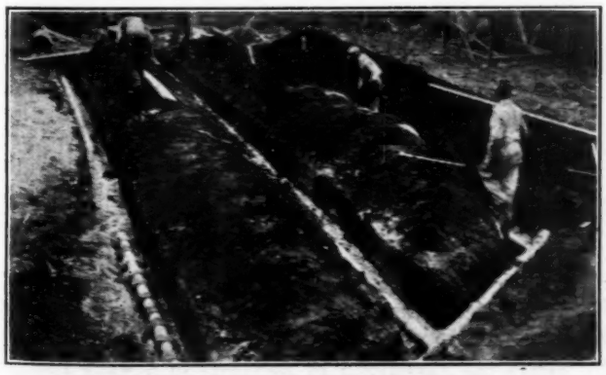
DOUBLE PIT COMPLETED READY FOR SEATS AND HOUSE.

is due to the fine results from this health work; but sanitation is the foundation of all health work, and without it other work produces small results.

Theoretically almost ideal, the box and can is far from perfection practically. The cans rust and begin to leak in about a year; the backs of the boxes, through which the filled cans are removed and the empty cans inserted, warp, split, and break, allowing flies to enter; the hinges on these backs also rust and stick, preventing the back from closing tightly, or break; seat lids are left up, inviting the presence of flies by the accessibility of the can contents. Frequent and continuous inspection is necessary to maintain these toilets in fair conditions; to keep them in first-class condition is practically impossible. Moreover, their sanitary efficiency depends very largely upon the care and intelligence of the scavenger. If he is careless and without interest in or knowledge of sanitation, much of the benefit of the installation is lost. About the only people who will accept the work of scavenging the toilets are negroes so decrepit or incapable that they cannot make a living elsewhere. They have no knowledge of public health principles; sanitation means nothing to them.

Recognizing these facts, the city has adopted the earth pit toilet as a standard installation for places where running water is not available, and the small septic tank for those places where water is available. While this standard was adopted nearly three years ago, the ordinance requiring this type of toilet was not passed until early in 1925.

As shown in the illustration, the pit toilet consists of a hole in the ground about 3 feet square and 5 feet deep, curbed around the top with concrete, and surmounted with a concrete floor in which is set an iron seat riser. Experience has shown that such a toilet retains its sanitary qualities over a long period of time, while the pit, under ordinary conditions of use, will serve the average family for five or more years before it becomes filled. No scavenging is required; when the pit becomes filled to within 18 inches of the ground surface, another pit is dug, the house and concrete slab moved, and the old pit filled in. Odors are almost eliminated as compared with the box and can toilet, and the difficulties of scavenging are done away with, as well as the passage through the streets of the scavenging wagons, always a source of many complaints. The danger of contamination of ground waters by pits constructed in this fashion is almost negligible if a slight degree of care and common sense is used in locating the toilet.



METHOD OF INSTALLING SUB-SURFACE LINES FOR DISPOSING OF EFFLUENT FROM SEPTIC TANKS.

In the past three years, nearly 6,000 pit toilets have been installed in and around Birmingham and, under practical conditions, have proven highly satisfactory. It is the intention of the city to replace, within the next year or two, all box and can toilets with the pit.

While slightly higher in first cost, the pit requires no scavenging, which for the box and can toilet costs $6 per year. In three years, the saving in cost by the elimination of the need of weekly scavenging will pay for the installation of the pit.

Many years ago "yard" toilets were installed in the poorer sections of the city. One flush toilet installed out of doors might serve 6, 8 or even 10 negro homes. These soon become so filthy that many of the tenants will not use them, and ground pollution results. It is now proposed to replace these with pits. Instead of being a backward step, this will have an important effect on health, it is believed.

With many fine homes going up in the numerous subdivisions being opened up just out of reach of the sewers, some method of sewage disposal for the individual home is vitally needed. The cess-pool does not work well in the tight soil of Birmingham, and is a nuisance, frequently overflowing and nearly always a source of annoyance to the neighbors. The small septic tank has been adopted as a standard for this type of installation. Home made tanks are discouraged, as a rule, for everyone, it seems, has his own idea as to what a small septic tank should be in size, dimensions, and design, with the result that many of these home-made tanks give trouble. Commercial tanks of the style shown in the illustration are recommended, and emphasis is laid on the details of installation, which, when a reasonably good tank is used, are more important anyway. For disposing of the tank effluent, sub-surface irrigation using at least 100 feet of tile line laid in not less than 5 yards of slag, broken stone or gravel, as shown in the illustration herewith, is required.

More than a thousand septic tanks have been put into operation in and around Birmingham in the past two years. Of those installed under the direction of the city but one has given any trouble, except from abuses or overloading; while of those installed by self-styled experts, about 40 per cent give trouble within a year. The strict regulations of the city in regard to the size of the tank and the construction of the tile line have been fully justified.

By the elimination of the "yard" and box and can toilets, and by the installation of pit toilets and small septic tanks, even though there is little chance that the immediate future will see any material reduction in the number of unsewered homes, it is hoped to reduce still further

the typhoid and colitis rates, which even now compare very favorably with those of any other Southern city.

Substitutes for Sewerage

The use of the pail system and requirement of residential septic tanks and sanitary privies for residences not served by sewers.

More than half the cities reporting to us last June stated that less than 80 percent of their residences were connected with sewers. Quite a number reported only 30 to 50 percent. (The figures will be found in the July issue.)

We asked in the questionnaire that information also be given concerning plans employed for sewering the homes for which sewers are not accessible. Of the several hundred replying, only forty-three reported any system other than the use of tank wagons, barrels, etc., for removing night soil, some city-owned but the majority operated by private contractors.

Of the special systems employed the pail system was the most popular. This was reported by 14 cities in Alabama, Florida, Louisiana, Minnesota, North Carolina, Ohio, South Carolina, Tennessee, Virginia and Washington. Four others use the "can" system in Georgia, South Carolina and Texas; two, in Illinois and Texas, removal in wooden boxes; and one in North Carolina, in buckets.

Septic tanks are required under certain conditions in four cities in Alabama, Georgia, New York and West Virginia.

Sanitary privies are required in one Alabama and one Florida city. Sanitary dry closets in two Virginia cities.

While not a removal system, the cesspool is an improvement over the ordinary outdoor privy, and was reported by thirteen cities as required. These cities are in California, Illinois, Iowa, Massachusetts, Minnesota, Montana, New York, Pennsylvania, and Washington.

In the twenty cities using the pail, can and wooden box systems, the number of residences connected with the sewers average 71 per cent, connected, with a minimum of 80 per cent.

The cities requiring septic tanks are much more thoroughly sewered, averaging 89 per cent connected with a minimum of 80 per cent.

Those requiring sanitary privies and closets average 69 per cent connected, with a minimum of 50 per cent.

Those requiring cesspools average 75 per cent with a minimum of 30.

In general it is found that the systems requiring the least expenditure by the householders are used where the greatest percentages of residences are not connected, and where there is the greatest percentage of the poorer class. On the other hand, septic tanks are required in none of the reporting cities having more than 20 per cent unsewered residences.

In addition to the cities included in the above analysis, there are many which maintain more or less control over the disposal of excreta, several supplying a removal service. Of these, Jacksonville, Fla., with 70 per cent of the residences sewered, reports the use of 5,000 earth toilets, from which the excreta is removed by tank wagons at night and dumped into a sewer, through which it is flushed by water from a 4-inch pump. The city expected to spend $1,000,000 on extension of the sewerage system if a coming bond election is carried.

Birmingham, Ala., believes that it has adopted the most complete system for handling this problem, which is described in a special article elsewhere in this issue.

Sewage Treatment at Newark, England*

Description of plant operated on a somewhat new system, after six months of service treating a sewage strong with brewery waste.

Before describing these works, we should like to explain what we tried to achieve at Newark. We have tried to invent an activated sludge process which could be easily and cheaply added to existing filter works, and which would have the effect of doubling their capacity. This system would only absorb about 6 h.p. per ½ million gal. of sewage, which is very much less than other activated sludge systems. The system could be stopped without damage for a part of the night. We think by its aid a filter works having a capacity of 250,000 gal. could be increased to 500,000 for about £2,000, not counting any alterations to storm water or mud treatment.

DIFFERENCE BETWEEN NEWARK AND MOST OTHER ACTIVATED MUD SYSTEMS

The usual activated mud system consists of mixing activated sludge and sewage together and agitating the mixture for long periods (16 hours) to keep the mud from settling and to keep the surface moving to enable oxygen to be absorbed. It is of course expensive to agitate the whole of the sewage for long periods. We have only to agitate the mud, not the sewage and mud. Our mud settles slowly through the sewage and the slower it settles the less mud we have to pump to maintain contact. We rely on the sewage discharging upwards just below the surface of the tank to keep the surface moving and enable the mixture to absorb oxygen.

DESCRIPTION OF THE NEWARK PLANT

The population of Newark is now about 17,000. Its crude sewage was discharged into the Trent at

*Slightly condensed from a paper read on June 13th before the Association of Managers of Sewage Disposal Works.

seven different outfalls. We laid a deep collecting sewer and brought the sewage to the present works. The sewer was laid in waterlogged ground, but tests proved it to be absolutely watertight.

We provided for 20,000 population at 20 gal. per head, and allowed for a trade waste of 100,000 gal. per day. Newark contains many breweries, and its sewage is about 20 per cent. brewery waste. It is therefore difficult to purify. It varies considerably, the oxygen absorbed figure ranging from 8 to 16 parts per 100,000 in four hours.

As Newark is one of the last towns on the Trent, full purification was not asked for. After consultation with the Ministry, it was decided only to partially purify the sewage and to design the scheme in such a manner as to enable filters to be added if full purification was afterwards decided upon. The sewage is settled and partially purified by activated sludge. If filters are afterwards added not more than half the ordinary capacity would be installed, as the partial purification would increase the capacity of the filters by 100 per cent.

The sewage is separated by a separating weir, up to three times the normal being treated as sewage; and over three times and up to six times, as storm water. Over six times passes straight to the river.

The storm water is settled in two tanks, having a capacity of one-eighth the dry weather flow. The mud is extracted and passed to mud beds, the tank effluent passing to the storm area and thence to the river.

There are five pairs of 18 ft. square Dortmund tanks. Each pair are in parallel and the five pairs in series. The mud reconditioning chambers consist of 8 ft. square chambers, allowing 9 in. depth of mud, and fitted with revolving scoops which dip about an inch into the mud surface and agitate it as the scoops whirl round.

There are four mixing and aeration chambers 13 ft. square and fitted with revolving scoops which also dip an inch under the surface. Sewage runs into the second of these chambers at one end and mud at the other; the scoop mixing them together. The remaining chambers can be used if it is desired to employ any of the other tanks for activation. At present they are used for aeration.

SEWAGE PROCESS

The sewage first receives preliminary settlement in No. 1 and 2 pairs of Dortmund tanks, the mud being extracted and dried on mud beds. The mud is continuously extracted from the bottom of the third pair of Dortmund tanks and pumped into the reconditioning chambers where it is activated and then flows to the mixing chamber where it is mixed with the sewage. The mixture flows into the third pair of Dortmund tanks, from which the sewage passes to No. 4 and 5 pair of tanks where it is finally settled and goes to the river.

The activating scoops and mud pumps are only run for 16 hours in the 24. It would, of course, be better if the activating scoops alone were run another three or four hours as the mud tends to lose condition duing the eight hours rest.

You will appreciate that the process is new, and like all new things we have to slightly modify and alter to get the best results.

The Newark sewage, containing 20 per cent brewery waste, is a difficult sewage; its mud takes a long time to activate. We hope to treble the capacity of the mud activating tanks by merely lifting the scoops 18 in., which we think will greatly improve the result. We should also disengage the scoops from the three aeration chambers and thus reduce the h.p. used.

In addition we should like to put down deep scum boards in No. 3 tanks, so that we could deliver the mixture nearer to the surface for the mud to take longer to settle. We are certain the above small additions would greatly improve the results.

The exact amount of mud to use can only be ascertained by experiment with a particular sewage. We are now trying a 2½ per cent mixture. That is, a sample taken from the mixing chamber where the activated mud and sewage are mixed should show after settlement 2½ per cent of mud and 97½ per cent sewage.

The Dortmund tank which receives the mixture should be kept as well sludged as possible, otherwise the mud in the tank is apt to turn septic and spoil the activated mud when it enters the tank.

The activated mud when mixed with the sewage should be preventd from settling as long as possible in order to allow it to purify the sewage. We think a satisfactory result should be obtained by an hour's contact.

We have been using 7 h.p. per 500,000 gal. of sewage for activation and mud pumping combined. We are now reducing the amount of mud pumped and removing the three scoops in the aeration tanks. We anticipate using not more than 6 h.p. in future, of which the agitation will absorb about 3 per cent.

SUGGESTED DESIGN

In designing a plant of this kind for treating 500,000 gallons a day, we should use the first tank for preliminary settlement, the mud going to the land. The second tank would be the mixing tank. A long activating chamber 60 ft. by 12 ft. and 2 ft. to 3 ft. deep with six revolving scoops would be used to activate the mud which would be continuously drawn from No. 2 tank. After activation the mud would be mixed with the sewage and discharged upwards 18 in. beneath the surface of No. 2 tank. Deep scum boards would prevent the mud being washed over the weirs. The surplus mud from this tank would go to the land. The third tank would be used for final settlement. The tank effluent would then pass to the filters. A small engine using 6 h.p. would be necessary to drive the scoops and run the mud pump.

One of the advantages of the process would be that it need not be run during the night. The night flow of sewage could be dealt with by the filters alone in gravitation schemes, and could be stored in small pumping schemes. If the rest period was as long as eight hours, it would be advisable to continue to run the mud scoops in the reconditioning chambers for half the period of rest in order to keep the mud in good condition. No mud, however, would be pumped during this time.

The running costs are trifling, the only labor required being sufficient to keep the engine running.

Sewerage Plans for New Jersey Municipalities

Changes made last month in the rules and regulations of the State Department of Health of New Jersey governing the preparation and submission of plans for sewerage and sewage treatment works proposed for construction in that state.

In 1922 PUBLIC WORKS published, in a series of articles, abstracts of and excerpts from the rules and regulations of the several State Boards of Health relative to the preparation of plans for sewerage and water supply, which by law must be approved by the board before constructed and used. Among these were the regulations of the New Jersey Department of Health, adopted in 1913. These have been revised and brought up to date, and in their new form the regulations were adopted by the department on August 11th. They have not yet been printed for distribution, but through the courtesy of H. P. Croft, chief engineer of the department, we have been able to prepare, from a typwritten copy, the following abstract of the changes and additions made in the regulations relative to sewerage, and expect to give next month those relative to water supply.

SEWAGE—GENERAL

Instead of one copy of plans and specifications, three sets must be furnished, one to be stamped, and returned, and two (one on cloth) for filing with the department. Dimensions over all shall not exceed 18″ x 36″ for detailed plans and 24″ x 36″ for general plans.

To the information required is added specifications for sewer lines, and estimate of cost.

For lettering, preference is expressed for "large vertical block letters for titles and main features, and slanting letters for all notes, elevations and minor features."

"With the profiles for sewer extensions shall be included a map showing all existing sewer lines within a distance of two blocks of the district to be sewered as well as the proposed sewer lines."

Plans for the treatment plant must show "all buildings within 500 feet of the plant property."

When the proposed sewers are to receive sewage from, or discharge into the sewers of, an adjacent municipality or district, a copy of the contract covering such use must be sent.

Sewers shall be designed for carrying not less than 20 gallons per foot of sewer, with 8-inch as the smallest size used. They "shall be of glazed tile, concrete, brick, or segmental block, except in the case of inverted siphons or where unusual strength is required, when sewers shall be of cast iron."

"Distances between manholes must not exceed 500 feet for sizes 18 inches or less. A drop pipe shall be provided for a lateral sewer entering a manhole above the manhole invert."

Pumping Stations. At least two pumps are required, each capable of handling the entire peak load. If electrically driven, an auxiliary source of power must be provided. "Electrical motors must be so placed as to be protected from flooding. Pumps should preferably be in a dry well or else installed so as to be readily removable for repairs and cleaning. In all cases raw sewage must be screened before pumping. An electrical warning device must be installed to give warning of pump breakdowns, clogging, etc."

SEWAGE TREATMENT

The regulations relative to sewage treatment plants are new, and are quoted in full below.

General Requirements for Sewage Treatment Plants:

1. A suitable building, preferable heated, should be provided at each plant for workshop, etc.
2. A weir manhole must be installed with either a V-notch or rectangular bronze plate weir, so located that correct measurements of the flow can be taken. Recording gauges must be installed.
3. A source of water supply must be provided.
4. The specifications must include a complete outfit of tools and accessories for the plant operator's use, such as squeeges, portable pump, putrescibility outfits (if required), rakes, shovels, etc.
5. The plant design must be laid out with a view to ease of operation, making provisions for walkways on tanks, roadways around beds, etc.

Minimum Requirements for Sewage Treatment Plants:

1. *Capacity of Plant*:

Plans for sewage treatment plants to serve a new sewer system for a municipality or sewer district will be examined and compared on the basis of a minimum average flow of 100 gallons per capita per day, to which flow must be added industrial wastes; for institutions, dwellings and boarding schools, a minimum average flow of 100 gallons per capita per day; and for industrial establishments (sanitary sewage only) and day schools, 50 gallons per capita per day. With these rates bituminous joints or equal must be used in the sewer system, otherwise the rates quoted above must be increased by 25%. Plans for sewage treatment plants to serve an existing sewer system will be examined upon the basis of gaugings of the present flow from the sewers, plus 100 or 125 gallons per capita per day for future extensions and estimated future population.

The plant must be designed for at least a period of ten years.

2. *Mechanical Screens*:

Specifications must contain guarantees of the screen efficiency. Screens shall be in duplicate. The width of the slots or openings shall not exceed one-sixteenth of an inch. The method and location of the disposal of screenings shall be specified.

3. *Single Story Sedimentation Tanks (without separate sludge digestion)*:

(a). Two or more compartments are to be provided.

(b). The combined capacity of settling tank compartments, exclusive of sludge capacities, shall be at least 8 hours, based on average flow. No compartment shall have a detention period less than 2 hours, exclusive of sludge. The total sludge capacities of all compartments shall be equal to a volume computed on a basis of 2 cubic feet per capita.

(c). Ratio of length to width shall not be less than 1 to 3, nor more than 1 to 5.

(d). Depth below water line shall be not less than 6 feet.

(e). If hoppers are provided, the slope shall be not less than 1 horizontal to 1 vertical.

(f). If flat bottom, a 2 per cent slope to sump shall be provided.

(g). If sludge withdrawal pipes are provided (hopper bottom), minimum head on riser shall be 4 feet.

(h). Scum boards shall be provided at inlet and outlet ends of tank.

4. *Single Story Sedimentation Tanks (with separate sludge digestion)*:

(a). The detention period in the settling tank, based on average flow, shall be not less than 4 hours.

(b). Sludge storage space in digestion tank, shall be not less than 2 cubic feet per capita.

(c). Means for complete removal of sludge from settling tank are to be provided.

(d). Means must be provided for the circulation of the sludge in the digestion tank.

(e). The overflow from the sludge digestion tank must be treated.

(f). Other requirements are the same as for plain one-story sedimentation tanks.

5. *Imhoff Tanks*:

(a). Detention period shall be not less than 2½ hours based on average flow.

(b). Ratio of length to width shall be not less than 3 to 1, or greater than 5 to 1 (rectangular tank.)

(c). Baffled inlets and outlets must be provided in flowing-through compartments, and the slope of the walls of such compartments must not be less than 1 horizontal to 1¼ vertical; slots shall be not less than 8 inches wide with an overlap of at least 8 inches.

(d). The inlets and outlets must be so designed as to equally distribute the sewage flow between the various compartments of the tanks.

(e). For more than one sludge digestion compartment full width openings in division walls must be provided, as well as means for the reversal of sewage flow.

(f). In tanks 25 feet or more in depth, a minimum capacity of 1.75 cubic feet per capita must be provided in the sludge digestion compartment; if less than 25 feet in depth, 2 cubic feet per capita is required. The capacity of the sludge digestion compartment is to be measured from a plane 18 inches below the point where the sloping walls of the flowing-through compartment, if extended, meet. The floor of the sludge digestion compartment shall have a slope of at least 1½ horizontal to 1 vertical.

(g). Sludge pipes shall be not less than 8 inches in diameter with a minimum discharge head of not less than 4 feet on riser pipe. Individual valves must be provided to control the flow from each sludge digestion hopper.

(h). Pipes must be provided to admit fresh water under the slots.

6. *Dosing Tanks*:

(a). Net capacity for sprinkling filters shall be 0.5 to 1.0 per cent of average daily sewage flow.

(b). Net capacity for sand beds shall be sufficient to flood bed being dosed, with 2 to 4 inches of sewage.

(c). Siphons shall have sufficient capacity so that the discharge rate at all tank levels shall be greater than the maximum inflow to dosing tank.

(d). A proportional flow design is preferred in tanks for dosing sprinkling filters.

7. *Contact Beds*:

(a). Contact beds must be preceded by sedimentation.

(b). The depth shall be from 4 to 8 feet.

(c). The material shall be uniform between 1 inch and 2 inches in size.

(d). The rate shall not exceed 125,000 gallons per acre per day per foot of effective depth.

(e). Intermittent dosing is required, with provision for resting individual beds.

(f). Complete underdrainage of the beds is required.

8. *Sprinkling Filters*:

(a). Sprinkling filters must be preceded by sedimentation.

(b). The depth shall be from 5½ to 8 feet.

(c). The material shall be uniform in size 1 to 3 inches.

(d). The rate shall not exceed from 1,650,000 gallons to 2,500,000 gallons. Rate governed by depth of filter.

(e). Net head on nozzles shall be not less than 4 feet.

(f). Half nozzles are to be provided at edge of bed.

(g). A secondary settling tank is required; if flat bottom, 2 compartments. Total detention period required, based on average flow, 1 hour.

(h). A means for flooding sections of the filters is desirable.

9. *Sand Filters*:

(a). Rate, if preceded by efficient sedimentation and if the effective size of sand is between .3 and .5 millimeters with a uniformity coefficient less than 3.5, must not exceed 150,000 gallons per acre per day.

(b). The minimum depth of sand required shall be 2½ feet.

(c). The minimum depth of the gravel or the stone over entire floor of the bed and underdrains shall be 6 inches. Gravel or stone shall not be mounded over the underdrains. Underdrains may be laid on boards in valleys dug in the floor of the bed, provided that sufficientt material be excavated so that at least 6 inches of the stone or gravel be placed on each side of the underdrains. The stone or gravel shall be graded from 1½ inch size on the bottom and around the underdrains to ¼ inch size to form the mat or bearing surface for the sand layer.

(d). Muslin, cheesecloth or burlap covered joints are required on underdrains; the joints are to be spaced ¼ inch apart.

(e). The maximum spacing of the underdrains shall not exceed 12 feet; lateral tile underdrains shall be not less than 4 inches in diameter.

(f). No ventilators or manholes shall be constructed in the sand beds.

(g). When the width of the sand filter exceeds 50 feet, more than one distributor must be provided.

10. *Disinfection*:

1. Capacity must be provided to give the following dose on average sewage flow,—

(a). Tank effluents, up to 20 parts per million available chlorine.

(b) Sprinkling filter effluents followed by secondary sedimentation, up to 18 parts per million available chlorine.

(c). Sand bed effluents, up to 12 parts per million available chlorine.

2. Contact tank must be baffled and have a detention period of at least ½ hour, based on the average sewage flow.

3. Hypochlorite of lime apparatus must have duplicate tanks, 24 hours storage, on a basis of 2 per cent solution.

4. Provisions shall be made for the thorough mixing of the disinfectant and the sewage before entering the detention tank.

11. *Sludge Drying Beds*:

1. Minimum area required.

(a). For one-story flat bottom sedimentation tanks, contents of one unit measured 8 inches deep as drawn.

(b). For Imhoff and hopper bottom tanks, 1.00 square foot per capita.

(c). For separate sludge digestion tanks, 1.00 square foot per capita.

(d). For final settling tanks, .25 square foot per capita.

(e). For glass covered sludge drying beds, ½ of the above area.

2. Sludge drying bed effluents are to be treated when discharged into waters used for potable purposes, for bathing, for growing of shellfish, or where the dilution is low.

3. Sand, gravel and underdrains are required as for sand filter beds, except that the sand may be reduced to not less than 6 inches in depth.

12. *Outfalls*:

1. Pipe must discharge below low water elevation. Manholes are required on the outfall line.

2. Ocean outfalls at bathing beaches must be at least 1,000 feet in length from mean low water mark.

13. *Activated Sludge and other Processes not heretofore Defined*:

No definite requirements are made for these processes. Each installation will be considered separately.

No by-passes which may allow raw or partly purified sewage to be discharged from the sewers or treatment plant shall be installed, except by special permission of the Department. By-passes, if permitted by the Department, shall be so constructed that they can be sealed. A detail plan of such by-passes must be submitted.

Survey of Sewer System

The Department of Streets and Public Improvements of Jersey City, New Jersey, Michael I. Fagen, Director, has realized for some time that there were parts of the sewer system for which no records were on file and in April, 1923, a sanitary survey of the entire sewer system of the city was started. This survey located several miles of sewers concerning which there had previously been no record, and also sizes and correct locations of sewers and manholes, and the depth of the sewers at each manhole.

As one of the interesting results of the survey, it was discovered that the sewage in some of the sewers was highly charged with oil which created a fire hazard at and near their outlets and also depreciated the value of the coastal real estate in the vicinity. Also an inspection of the quantity of flow at each manhole resulted in discovering a number of leaks in water mains nearby; in fact, the discovery and stopping of these leaks saved enough waste of water to pay the entire cost of the survey.

Runoff Experiments in New York

Experiments on rainfall and runoff to the sewers are being conducted in New York City by the Committee on Sewer Capacity. Three tipping-bucket rain gauges and two water stage recorders for the East New York area have been installed and started operation on May 1st. Two tipping-bucket rain gauges were placed in Manhattan Borough, one on Altman's store and one on Saks' store.

According to the Sewage Disposal Bulletin of the Board of Estimate and Apportionment for July, it was proposed to let in the near future a contract for a gauging manhole and venturi flume on 41st street. The Duplex Au water stage recorder to be used will record on one chart the elevation of water surface in the entrance and in the throat, but where there is no interference from backwater, experiments have shown that discharge may be determined by the elevation in the entrance only.

PART OF QUEEN MARY'S RESERVOIR EMBANKMENT, SHOWING LINING OF CONCRETE SLABS.

Queen Mary's Reservoir

English reservoir said to be the largest in the world entirely enclosed by an artificial embankment, covering 723 acres.

There has recently been completed in England a reservoir known as the Littleton reservoir, officially Queen Mary's reservoir, which is said to be the largest in the world that is entirely enclosed by an artificial embankment. This reservoir covers about 723 acres and has a capacity of nearly 7,000 million gallons, the depth averaging about 38 feet.

This reservoir was built by the Metropolitan Water Board of London to supplement the storage of water for that city. The work was performed under the direction of the chief engineer of the board, Henry E. Stilgoe. The site of the reservoir was selected in 1911 and plans were prepared. Work was commenced in 1914 but proceeded very slowly because of the war, and work on it was completely suspended in 1916 by the order of the Ministry of Munitions. Work was renewed in 1919 under a contract with S. Pearson, Ltd.

The reservoir is located three-quarters of a mile north of the Thames river between Staines and Shepperton. Water is drawn from the Thames river, the intake being beneath the three arches of a large concrete bridge faced with granite. Thence the water proceeds through an open channel for three-quarters of a mile to a steam power pumping station which discharges the water through steel pipes into the reservoir. The water is used to supplement supplies for both the north and south sides of London. Part of the supply flows from the reservoir through reinforced concrete aqueducts into the Staines aqueduct, which passes close to the north side of the reservoir, and the rest is conducted by

INTAKE ARCHES AND SLUICES.

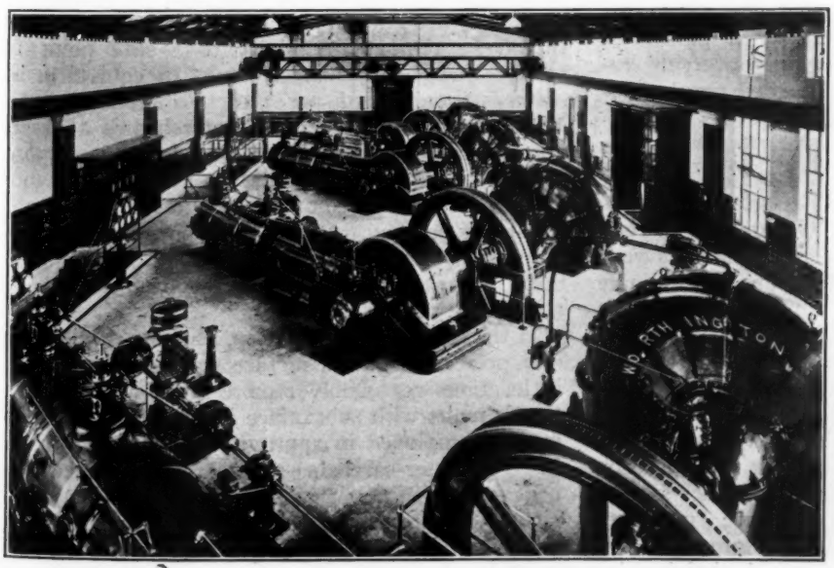
aqueducts to Kempton Park, where the Metropolitan Water Board has reservoirs and filters.

The reservoir is an irregular seven-sided polygon with rounded corners about a mile and a quarter across. The embankments are of earth with a clay puddle core carried down into the London clay which underlies the whole region. The land here is comparatively level and the bottom of the reservoir was excavated to an average depth of about 6 ft., the material so removed being used for the embankment. The embankments rise about 38 ft. above the original ground level and have a slope of 3 to 1 on the inside and 2½ to 1 on the outside. The outside face of the embankment was covered with rich soil and loam and will be landscaped with ornamental shrubs. The inside slope is protected from wash by concrete slabs six inches thick. The normal water level will be about 6 ft. below the top of the embankment.

The pumping into the reservoir is done by four Worthington-Simpson horizontal steam-driven centrifugal pumps with a combined capacity of 343 million gallons per twenty-four hours against a head of thirty ft., or 250 million gallons against a head of 46 ft., the revolutions being 125 and 140 per minute respectively. The engines are of the Worthington Uniflow type, each of 770 horsepower, single cylinder. The most modern devices are used in handling coal and ashes in the boiler room.

Fine Ground Cement

The Bureau of Standards, Department of Commerce, has just completed a ten year research, one of the results of which is proof that fine grinding of cement makes concrete stronger, especially if greater amounts of cement are used with the sand and gravel. That fineness is a vital characteristic of portland cement has long been known, but the data were lacking as to the exact effect of such fineness over long periods of time. The tests referred to began ten years ago with the construction of test cylinders of concrete made up of five brands of cement mixed with sand and gravel. These were broken after six months, 1, 2, 3, 5 and 10 years. The older specimens showed less increase due to fine grinding, but the advantage of such grinding was shown conclusively.



PUMPING PLANT AT QUEEN MARY'S (LITTLETON) RESERVOIR DRIVEN BY FOUR 770 H.P. WOTHINGTON-SIMPSON ENGINES.

Watershed Protection

Present ideas and practices. Ownership, physical character, elimination of nuisances, laboratory control, legislation, and enforcing regulations.

The committee of the American Water Works Association appointed to consider watershed protection submitted a comprehensive report at the 1925 Convention, which summarizes in a comprehensive way the present status of ideas and practices. An effort is made in the following synopsis to present the principal features of this report.

It is a generally accepted principle today that no suppply taken from a major stream subject to any considerable pollution, even though the dilution factor be great, can be considered safe as a public supply unless subjected to suitable purification processes —in most instances filtration and chlorination. The tendency appears to be away from dependence upon preventive measures on the watershed in lieu of purification processes at the intak. All surface supplies are considered potentially dangerous and cannot be considered safe without protective features.

The "uninhabited" watershed exists more in fiction than in reality. The automobile has opened up to the public regions heretofore nearly inacessible and all watersheds may now be invaded by the automobilist, fisherman, hunter and camper or picnicker.

As a first line of defence there may be adopted purchase of the watershed, adequate patrol, exclusion of sewage from the streams, where possible, and adequate treatment of community sewage. These, either singly or combined, are valuable aids, but cannot be considered as a complete solution.

As a second line of defence, we have long-time storage, chlorination and filtration. The first reduces bacteria and improves the quality of the water by means of sedimentation, aeration, sunlight and dilution. These, however, may be nullified by short-circuiting, seasonal overturn, reinfection of the water at or near the intake, or by accidental or incidental pollution. This possible nullification has led to the practice of sterilizing surface supplies. This, however, should not be

alopted as the only safeguard, perhaps, in the few cases where the water is always free from turbidity. To be effective, sterilization should be continuous, or possibly omitted during midwinter where the watersheds are remote or inaccessible.

Finally, unless water of a high sanitary quality can be continuously secured as a result of these preliminary measures, as demonstrated by suitable tests, filtration and sterilization are indicated.

Watersheds of public water supplies throughout the country may be generally divided into four main types:

1. Relatively large inhabited watersheds where conditions are such as to require filtration.
2. Very small watersheds, uninhabited and controlled by the water works authorities and where there is little or no storage in impounding reservoirs.
3. Watersheds with storage reservoirs large enough to hold the average run-off of many months or a year or more.
4. The intermediate type of watershed, relatively small, exposed to pollution, where filtration is not adopted and where geological and other conditions are such that a moderately satisfactory water supply is procurable in the absence of filtration, provided that the protection of the watershed is given due care.

The first type is beyond the scope of this report. Local conditions will usually govern the measures necessary on watersheds of the second type. Patroling, placarding, or entire ownership are likely to be the most effective; but danger from the incidental pollution arising from tresspassers must not be lost sight of.

In the case of areas of the third class it may be found that long-time storage with satisfactory sterilization will permit a reduction of other protective measures above the intake employed for class 2. The necessity of keeping the watershed in as clean a condition as possible should be a large factor in final decision as to the measures to be employed.

Class 4 probably embraces more supplies than any of the others. Protection of this type of watershed involves ownership, physical character, data of water-borne diseases, the elimination of nuisances, the use of the laboratory, legislation conferring authority, and means of enforcing needed regulations. The report discusses each of these seven points.

OWNERSHIP

Purchase of all the watershed is seldom possible and does not prevent trespass. Generally speaking, it is not worth while except where the land is very cheap, or where it is highly important to eliminate objectionable conditions which cannot otherwise be brought under control. It is usually economically better to spend the money in purification than in land purchase. Filtration affords better protection than ownership and if the cost of the latter approximates that of the former, filtration should be the alternative adopted. Moreover, it is probable that filtration will ultimately be necessary with any surface supply.

Marginal strips about reservoirs are sometimes purchased to prevent access to the shores or allow relocation of roads. They are of doubtful value as a means of reducing pollution in the majority of cases. They, however, if well kept, give the appearance to consumers that the water works officials are maintaining a clean and wholesome supply.

PHYSICAL CHARACTER

The topography, geological formation, shape, and location of a watershed have considerable bearing upon the effectivenes of the various methods of watershed protection. Precipitous, rocky areas, unsuited to cultivation, often give opportunity for protection by land purchase. Flat valleys and gentle slopes suited to cultivation are generally too valuable to purchase and other precautions must be adopted.

Porous sandy soils of considerable depth act as filters for polluted wastes, although in northern climates this may be destroyed in winter by freezing and ice-cutting. Where the surface soil is impervious, filth deposited on the surface will find its way into the water courses, and the same is true of seamy rock or coarse gravel near the surface.

DATA ON WATER-BORNE DISEASES

The early detection of cases of water-borne diseases on a watershed is an important duty of the watershed police. Immediate steps should then be taken to secure safe disposal of all wastes from the house sheltering a patient, and vigilance should be exercised to see that the special sanitary precautions are carried out until all traces of the disease have disappeared. The history of each case should be recorded with evidence as to source of infection, and if other inhabitants of the watershed were known to have been exposed to the suspected source, their health should be reported daily until the expiration of the maximum incubation period (about three weeks) and steps should be taken to compel their use of facilities provided for safe disposal of excreta and urine.

ELIMINATION OF NUISANCES

For isolated residences or small communities in seamy rock formations, watertight privy vaults of approved design should be used. The contents should be removed regularly to a safe point for burial. Sewage in chemical tanks or equivalent appliances should be disposed of in a similar manner. Water carried sewage on a watershed is a greater potential menace than where the excreta is disposed of by the dry method and its disposal is more difficult of accomplishment. If allowed, the sewage should be purified to the highest possible degree before being discharged into a stream. Sedimentation tanks followed by intermittent filtration and chlorination have proved effective.

If the soil is sandy and deep, leaching privies properly protected against surface wash may be allowed in locations reasonably remote from water courses. Septic tanks with subsurface irrigation or cess pools may be employed in approved locations for disposing of water-carried sewage from isolated residences, and broad irrigation on suitable land sufficiently remote from the streams to insure against drainage of any unpurified sewage to them may be used for the purification of sewage from small communities or institutions.

Zoning regulations are in force in some states. In Pennsylvania three zones are established on watersheds used as public water supplies; camping is not permitted within the first mile above the intake, within the second mile definite regulations must be observed, while the regulations are less stringent beyond this point. Similar zoning has been adopted in connection with the water supply of Decatur, Ill.

Lumbering on watersheds involves special problems of protection, as do railroad work trains and labor camps. Rigid enforcement of sanitary rules should be secured as far as possible.

LABORATORY CONTROL

In a number of the large cities unfiltered water supplies are controlled to better advantage by using water laboratories, making tests at frequent intervals at points known to be open to pollution and testing streams feeding reservoirs as well as the water in the reservoirs themselves.

LEGISLATION

A great many of the States have enacted legislation prohibiting polution of streams from which public water supplies are derived. There is a wide variation in the laws of different States which seems to be necessary because of various local conditions. Efforts should be directed to restriction by statute of all activities tending to markedly pollute unfiltered water supplies, or to pollute filtered water supplies to such an extent as to overload or threaten to seriously overload ordinary purification processes.

ENFORCING REGULATIONS

This involves an establishment of police patrol or inspectors on a watershed and punishment of violation of the rules.

For the former, some prefer using residents of the locality, while others favor patrol by men uniformed and clothed with authority, the latter chiefly on watersheds of the larger cities.

Concerning punishment, the courts have not ordinarily been of much help, as action is long delayed and juries are usually lenient to offenders. The remedy is not readily apparent, but it is suggested that the health authorities be given adequate power and appropriation to force property owners to promptly abate nuisances, or if they do not, to make an abatement and charge the cost against the property.

All measures which are or may be used for preventing the pollution of water supplies without involving unreasonable costs are well worth while, but are not thoroughly effective even when the entire watershed is owned by the water purveyor. Watershed protective measures should be most thoroughly carried out where the water supply is not sterilized or otherwise purified as the purity of such supplies largely depends thereon; but where assured purification is provided the steps taken to control the quality of the raw water may be satisfactorily and most economically directed toward the elimination of gross sources of pollution.

Hydrant Inspection by Firemen

Two hours daily for each fireman. What should be included in inspections. Remedying defects.

The Chief of the Fire Department of Elizabeth, N. J., August Gerstung, in a paper before the International Association of Fire Engineers, recommended a plan of inspection of fire hydrants during the winter months by firemen, where the hydrants are maintained by private corporations and not by a municipal water department, which he said had proven very satisfactory.

"Divide the city into as many hydrant districts as there are fire companies, allotting a certain district to each company under the command of the captain of the respective company. A man on duty is sent on a daily two-hour tour, reports in, and then another man goes out for two hours, and so on, covering the full period of said platoon. The next platoon does the same thing, with the result that each and every hydrant is inspected twice in every twenty-four hours. When a leaky hydrant is found, especial attention is given to it and is followed up with another inspection by a man on the next platoon."

By such inspection work the men gain knowledge of the exact location of each and every hydrant in their district, which in itself is well worth the time and trouble.

Mr. Gerstung then gave an excellent outline of what the inspection should comprise.

During the spring and fall inspections, the hydrant should first be subjected to a pressure test by opening the foot valve after drawing up the caps tightly; the result will prove the tightness of the hydrant caps and of the stuffing box. An aquaphone will, if placed against the top of the valve stem with the hydrant closed, indicate whether the main valve is tight.

Damaged condition of any part of the hydrant should be noted. Hydrant caps should have washers, be properly chained, with easy turning swivel ring, and be sufficiently tight to prevent mischievous children from removing them.

Particular note should be made of the condition of the threads on outlets. A standard coupling should be tried on each outlet and if the fit is too loose or there are worn threads these should be reported and corrections made.

The visibility of the hydrant should be noted and the hydrant painted if necessary.

For each hydrant there should be a record card on which should be noted the various features of the hydrant, date of inspection and condition.

After the pressure test has been made, one or two caps should be removed and the hydrant opened wide and flushed. After the dirty water has been cleaned out, the hydrant should be closed and observations made as to whether it drains properly. This can be determined by observing the speed with which the water level in the hydrant barrel drops after the foot valve is closed and the drip valve opened. If the hydrant does not drain freely, the obstructions may oftentimes be removed by replacing the caps and pumping up pressure in the hydrant barrel by means of a force pump which will in most cases remove obstructions from around the drip value and correct any fault in the drainage.

If there is considerable leakage at the stuffing box, the valve stem should be repacked and oiled. Slight leakage can

usually be stopped by tightening the stuffing box. The packing in the stuffing box should be oiled in any event since it is likely to dry out and result in leakage.

Operating parts, the valve stem particularly, should be oiled so that the hydrant may open easily, and the threads on the hydrant caps should be swabbed with grease or graphite.

During these inspections observation should be made as to obstructions which may have been erected near the hydrant such as telephone or telegraph poles or trees. Also as to whether there is sufficient clearance between the hydrant outlet and the ground so that the caps may be easily removed and the hose readily connected to the hydrant butt.

Another feature that should be observed especially in these days when hydrants are so frequently damaged by automobile trucks is whether they are sufficiently far from the curb to make such damage unlikely.

In conclusion, I do not deem it amiss to quote, that in a good many states and cities, the motor vehicle law prohibits parking 10 feet either side of a fire hydrant. This law, as a rule, was made prior to the advent of the modern pumper. The total of 20 feet space allowed is not sufficient for the modern automobile pumper, which ranges from 25 to 30 feet overall. It would be well, therefor, that the law be changed or municipal ordinances be passed prohibiting parking 20 feet on either side of the hydrant, allowing a total of 40 feet for apparatus to manoeuver.

Colors and Forms of Traffic Signals

Code Proposed by Sectional Committee of the American Engineering Standards Committee

The following is the text of a revised draft of the code of colors and forms for traffic signals for highways and vehicles submitted for approval to members of the sectional committee on code for traffic signals of the American Engineering Standards Committee.

The draft, which will probably be approved by the sectional committee, is as follows:

REVISED DRAFT OF CODE OF COLORS AND FORMS FOR TRAFFIC SIGNALS FOR HIGHWAYS AND VEHICLES

SECTION 1. PURPOSE AND SCOPE

Rule 10. *Purpose.*

The purpose of this code is to provide a standard of colors and methods, as applied to highway traffic and vehicles, which will promote uniform usage and thus decrease the likelihood of accidents, and conserve human life and limb. The approval of specific signs, glasses, or pigments as complying with the specifications herein contained should be based upon tests made by competent and disinterested organizations having proper facilities and recognized standing, with final appeal to the United States Bureau of Standards.

NOTE.—*To secure the uniform application of this code, enforcing officers are urged to consult the committee which formulated it (or the American Engineering Standards Committee, 29 West Thirty-ninth Street, New York City) regarding matters of interpretation or items of dispute.*

Rule 11. *Scope.*

This code is intended to cover the use of luminous and non-luminous signs and signals in connection with highway traffic, including moving and flashing signals, the use of lights, semaphores, and other signaling devices on vehicles.

SECTION 2. VEHICLE LIGHTS AND SIGNALS

Rule 20. *Headlights.*

(*a*) Headlights shall be white, amber, yellow, or any intermediate hue. If electric headlights are used, they shall conform to the rules governing the approval of electric headlighting devices for motor vehicles, of the Illuminating Engineering Society (tentative standard of the A. E. S. C. D2).

(*b*) No red or green lights shall be displayed upon any vehicle so as to be visible from a point directly in front of it.

Rule 21. *Tail Lights.*

Tail lights shall be red, as seen from the rear.

NOTE.—*Red has been adopted on account of its present universal use for this purpose. This use is not considered consistent with the general standardization of colors, and if a change is made in any jurisdiction, yellow is recommended.*

Rule 22. *Warning signal lights.*

(*a*) Light signals displayed on a vehicle to indicate the driver's intention to reduce speed or change direction should be yellow. They shall not be red or green.

(*b*) Nonluminous mechanical signals displayed to indicate the driver's intention to reduce speed or change direction shall consist of a semaphore which can be projected from the left side of the vehicle. It is recommended that the position of the semaphore when projected be limited to the horizontal.

Rule 23. *Marker lights.*

Marker lights to indicate the dimension limits of bodies or loads should be located as near the upper left front corner as possible and should be yellow and visible from the front and rear.

SECTION 3. HIGHWAY TRAFFIC SIGNALS—GENERAL

Rule 30. *Significance of colors.*

(a) Red shall be used as an indication to stop and for other purposes when required by law.

NOTE.—*The use of red is proper as an indication to stop and to then proceed if conditions are favorable, as, for example, when "stop" and "proceed" regulations are in effect.*

(*b*) Yellow shall be used as an indication to exercise caution.

NOTE.—*Yellow is appropriate when caution is to be exercised without stopping, as for partial street obstruction, so as to reserve red for a stop signal.*

(c) Green shall be used as an indication to proceed.

Rule 31. *Significance of form.*

Where definite forms of luminous or nonluminous signs or signals are used either alone or in combination with colors to give the indications specified in Rule 30, the following will apply:

(*a*) Stop shall be indicated by having the greatest dimension horizontal, as with a horizontal semaphore or string of lights.

NOTE.—*Where the word STOP is used to direct traffic, it should be in red letters arranged horizontally.*

(*b*) Caution shall be indicated by having the greatest dimension at an angle of 45° with the horizontal when an inclined semaphore or string of lights is used.

NOTE.—*Cautionary signs complying with Rule 33 may be used.*

(c) Proceed shall be indicated by having the greatest dimension vertical, as with a vertical semaphore or string of lights.

NOTE.—*Where the word GO is used to direct traffic, it should be in green letters arranged vertically.*

Rule 32. *Significance of flashing*

Flashing luminous signals shall conform to the use of colors prescribed in Rule 30.

Rule 33. *Cautionary signs for drivers.*

(a) Highway signs and signals of a cautionary nature for the notice of drivers shall have letters and symbols black on a yellow background or yellow upon a black background.

NOTE.—*It is recommended that all cautionary signs have a background of one distinctive shape, and that such shape be reserved for this purpose.*

(b) For signs to be read from vehicles in motion symbols are recommended in place of, or supplementary to, words.

NOTE.—*When both symbols and words are used, symbols should be given greater prominence.*

(*c*) When symbols are used, those illustrated in Figure 1 are recommended for the situation indicated. Other or

special symbols should be such as not to be confused with these.

NOTE.—*The symbol for the five-point road intersection is to be varied to fit each specific case.*

Rule 34. *Location of signs.*

(*a*) Traffic signs shall be erected with the top not more than 8 feet above the surface of the roadway.

(*b*) Traffic signs shall be erected at the outer edge of the shoulder area and on right-hand side of roadway where practicable.

Rule 35. *Cautionary signs for pedestrians.*

Signs addressed to pedestrians shall consist of blue letters upon a white background.

SECTION 4. SIGNALS AT RAILROAD GRADE CROSSINGS

Rule 40. *Aspect.*

An electrically or mechanically operated signal used for the protection of highway traffic at railroad crossings shall present toward the highway when indicating the approach of a train the appearance of a horizontally swinging red light and (or) disk.

NOTE.—*This covers the use of so-called wigwags and of alternately flashing red lights, and the use of these devices should be restricted to the purpose of indicating the approach of a train.*

Rule 41. *Location.*

The railroad standard highway crossing sign and the signal shall be mounted on the same post.

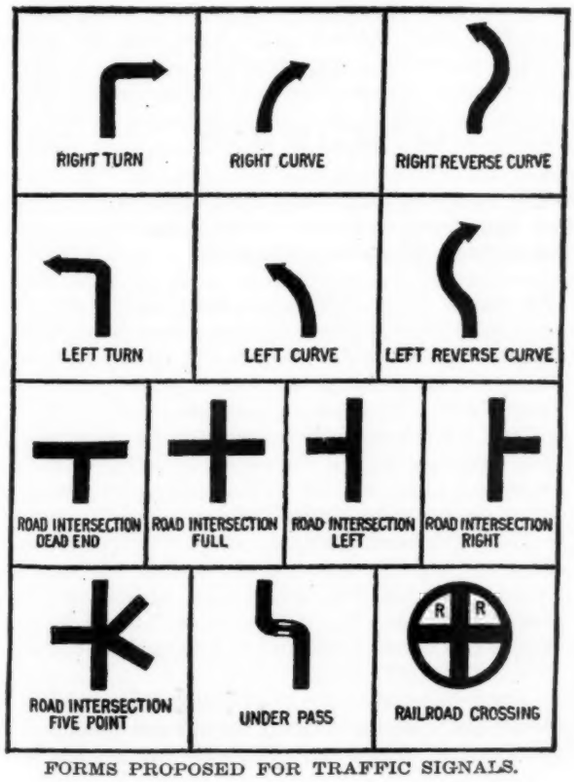
Rule 42. *Operating time.*

Automatic signal devices for indicating the approach of trains shall be so arranged as to indicate for not less than 20 seconds before the arrival at the crossing of the fastest train operated on the track. Local conditions such as three or more tracks, bad approaches, etc., should be allowed for by increasing the operating time, bearing in mind that too long an operation by slow trains is undesirable.

Rule 43. *Flashing light type.*

(*a*) *Height.*—The lamps should preferably be not less than 6 feet nor more than 9 feet above the surface of the highway.

(*b*) *Width.*—The two lamps shall be mounted horizontally 2 feet 6 inches centers.



FORMS PROPOSED FOR TRAFFIC SIGNALS.

(*c*) *Flashes.*—Lights shall flash alternately. The number of flashes of each light per minute shall be 30 minimum, 45 maximum.

(*d*) *Hoods.*—Lamp units shall be properly hooded.

(*e*) *Range*—When lamps are operated at normal voltage, the range, on tangent, shall be at least 300 feet on a clear day, with a bright sun at or near the zenith.

(*f*) *Spread.*—The beam spread shall be not less than 3° each side of the axial beam under normal conditions. This beam spread is interpreted to refer to the point at the angle mentioned where the intensity of the beam is 50 per cent of the axial beam under normal conditions.

(*g*) *Lenses or roundels.*—The size shall be 5⅜ inches minimum, 8⅝ inches maximum.

Rule 44. *Wigwag type.*

(*a*) Length of stroke is the length of chord which subtends the arc, determined by the center of the disk in its extreme positions, and shall be 2 feet 6 inches.

(*b*) *Disk.*—The disk shall be 20 inches in diameter. Its field shall be white with a black circumferential border 1 inch wide. The horizontal and vertical diameters shall be shown by black lines 2½ inches wide. A red lens or roundel should be placed at the center in front of the lamp.

(*c*) *Number of cycles.*—Movement from one extreme to the other and back constitutes a cycle. The number of cycles per minute shall be 30 minimum and 45 maximum.

(*d*) The lamp, with which the disk shall be equipped shall be lighted when the disk is swinging.

Rule 45. *Approach signal.*

Advance warning signals which indicate approach to a railroad crossing, and not the actual approach of a train, shall conform to the provisions of section 3, Rule 30.

SECTION 5. SPECIFICATIONS FOR COLORS

Rule 50. *Definition of Colors.*

Red, yellow, green, or blue as used in this code are intended to mean:

(*a*) The colors resulting from the transmission of the proper light through the proper glasses and having the characteristics described in Rules 51 and 52.

(*b*) The colors resulting from the reflection of white light from the proper pigments and having the characteristics described in Rule 53.

NOTE.—*For a definition of white light, reference is made to the report of the Colorimetry Committee of the Optical Society of America,* 1920-21 (*Journal of the Optical Society of America and Review Scientific Inst.* 6, *p.* 563; 1922). *Substantially, it is average sunlight at noon at latitude of Washington.*

Rule 51. *Qualitative definition of colors for luminous signals.*

(*a*) *Red.*—The spectrum of red shall contain both red and orange but not more than a trace of yellow and no green, blue, or violet. The most desirable hue is entirely free from yellow which means that the glass does not transmit the yellow light from a sodium flame.

(*b*) *Yellow.*—The spectrum of yellow shall contain red, yellow, and green, with but little blue and no violet. The most desirable hue is entirely free from blue and might be designated a light amber.

(*c*) *Green.*—The spectrum of green shall contain yellow, green, blue and violet, with only a trace of red and orange. This hue is known as "admiralty green" and has a bluish tint when observed by daylight.

Rule 52. *Quantitative definition of colors for luminous signals.*

The colors red, yellow, and green shall have the following characteristics:

	Dominant Wave-Length in Millimicrons	Purity	Integral Transmission of Glass
Red	not less than 624	not less than 100%	not less than 10%
Yellow	not less than 592 nor more than 600	not less than 97%	not less than 24%
Green	not less than 496 nor more than 536	not less than 45%	not less than 11%

These values are determined by the transmission of light from a source at the color temperature of 2.360° K (practically that of the acetylene flame or present type of vacuum tungsten lamp at normal voltage) through the respective glasses. They are based upon spectral transmission measurements and upon computations carried out in accordance with the methods and data described in the Colorimetry Report of the Optical Society of America.

NOTE.—*The light and dark limits of the glasses on which the above values are based have the following relative transmissions on the scale of the American Railway Association.*

	Light limit	Dark limit
Red	300	150
Yellow	200	100
Green	250	100

Rule 53. Quantitative definition of colors for non-luminous signs:

The colors red, yellow, green and blue shall have the following characteristics:

	Dominant Wave-Length in Millimicrons	Purity	Integral Reflection of Pigment
Red	not less than 608	not less than 60%	not less than 8%
Yellow	not less than 580 nor more than 588	not less than 80%	not less than 35%
Green	not less than 524 nor more than 552	not less than 30%	not less than 8%
Blue	not less than 466 nor more than 474	not less than 10%	not less than 4%

These values are determined by the reflection of white light from the respective pigments. They are based upon spectral reflection measurements under conditions of diffuse illumination and upon computations carried out in accordance with the methods and data described in the Colorimetry Report of the Optical Society of America.

Night Maintenance on Michigan Highways

Night maintenance of gravel roads was tried out the latter part of last year in Osceola county, Michigan, and was found so successful that State Highway Commissioner Frank Rogers decided to use it even more generally the present year. The Mackinaw Trail through Grand Rapids to Mackinaw is one of the main traveled roads into the northern part of that state and the large number of tourists' cars so interfered with maintenance by day that the night work was decided upon.

Maintenance of these gravel roads is absolutely necessary both to prevent the binding material from being dissipated by traffic and by winds and also to prevent the blowing of dust, which is not only an inconvenience to traffic but is a real danger, especially at grade crossings and curves.

The maintenance work, designated "floating," was done with trucks equipped with scrapers. These started out at 10 o'clock at night and completed the trip not later than 8 o'clock the next morning. They were equipped with spot lights and had no trouble in keeping on the road. During the first period of night road maintenance the results were carefully observed. On 60-mile trips two gallons of gasoline was saved and there was a marked improvement in the functioning of motors. In one week one inch less was worn off the blade than in the same length of time under day maintenance. Much of the dust movement during the floating was eliminated owing to the dew moisture on the roads and the light traffic.

If any of the trucks needed repairs these could be made during the day time when out of service, which was not always possible when the work was done by day. Trucks not being repaired were used during the day for hauling gravel and thus rendered the maximum amount of service and reduced the amount of machinery necessary. J. T. Sharpensteen, the resident road engineer, reports that this night road maintenance secures safety, convenience and economy on gravel roads carrying heavy traffic.

Report on California Highways

Brief summary of history of the State Highway System, less than half of which has yet been built. Maintenance and reconstruction most important. Construction details recommended. Highway finances.

In February, 1924, a committee was appointed under an act of the State Legislature of California with instructions to make a complete study of the whole state highway situation and report recommendations as to the best methods of outlining a proper system of state highways, the rate at which the state highway system can be constructed and the time which will be required to bring it to a state of completion, and "such other matters as may be incidental to those herein stated."

This committee consisted of seven citizens acting in conjunction with the state highway engineer and a member of the California Highway Commission, these including a state senator and state assemblyman, a newspaper man, chief engineers of two automobile associations, and a former county road commissioner and chairman of a county board of supervisors. This committee traveled by automobile over the entire state highway system and many roads advocated for additions thereto. Investigations were made both in the field and in the office of the commission and many public meetings and conferences were held. This was apparently done at the cost of the members of the committee, as no appropriation was made for its expenses. The committee reported early in 1925. The following paragraphs give some of the higher points of their report:

The California highway system practically began in 1909 with the passage of the first highway bond act for $18,000,000, which was ratified by popular vote in 1910. In 1916 a second bond issue for $15,000,000 was voted and in 1920 a third bond issue for $40,000,000.

Owing to the widespread demand for roads, those built under the first bond issue were mostly 4 inch concrete 15 feet wide. With the second bond issue

702 miles was added to the original 3052 miles of the state highway system, but by no means all of this could be built with the funds appropriated. With the third bond issue, 1853 additional miles were added to the system. While generally meritorious, they were not of such state-wide importance as the original trunk line system of roads, which were still far from completion. Moreover, the $40,000,000 appropriation would have been insufficient to build only the new roads added to the system by this bond act. In addition to the roads created as state highways by the bond acts, the Legislature has from time to time created certain other roads as state highways, which total 793 miles.

These additions have brought the total system of state highways up to 6400 miles. If the entire sum realized from these bond issues had been used for the entire system it would have provided an average of about $13,000 per mile, whereas construction to the standards now required costs above $40,000 per mile on the average and reaches $100,000 for some short stretches. Of the total mileage there still remains 3877 to be completed. The most important centers of population have been connected to a large extent and it becomes urgent that the major interstate connections should now be constructed.

Increasing traffic and increasing mileage of roads have caused the problem of maintenance and reconstruction to assume even more importance than new construction. According to traffic census counts made in 1920, 1922 and 1924, there was an increase of traffic amounting to 47% during the first two years and 43% during the second two years, while the increases in automobile registration during the same periods were 53% and 51½% respectively. On some days certain of the city entrances are so jammed with vehicles that several hours are required to move as much as twenty miles. On some roads travel has increased to the point where it is dangerous to any except experienced drivers even on normal week days. "The extent to which a given volume of travel crowds or endangers traffic on a road is determined fully as much by the character and safety of alignment as by width of pavement. For example, most drivers and passengers would very much prefer to risk a trip on the Coast road south of Santa Barbara on a big traffic day with 5858 vehicles, than on the Ridge road with 1854 vehicles. The Coast road at this point is paved for the most part only 15 feet wide and has reasonably good alignment, whereas the Ridge road is paved 20 feet wide, but has such crooked alignment as to be hazardous except for a limited volume of travel."

In this connection it may be noted that California has more automobiles per thousand population than any other state. In 1923 the automobile registration totalled one for each 3.35 persons and in 1924 one for each 2.92 persons and presumably the number has fallen still further for 1925. In several counties the number of persons per car was still smaller than the average. For instance, in Orange county the number per car was 2.14, in Los Angeles county 2.52 and in Kern county 2.62.

It was estimated that to construct the uncompleted portions of the state highway system would cost more than $217,000,000, of which $144,600,000 would be required for the 45 northern counties and $72,700,000 for the 13 southern counties.

MAINTENANCE

The maintenance of the state highways has reached its present magnitude because of the light nature of most of the early construction as well as the great increase in number and weight of vehicles. During 1924 the average expenditure per mile for general maintenance was $1,619, this not including such minor betterments as guard rails, drainage, removal of obstructions, etc.

There still remains about 400 miles of the roads included in the first bond issue which have not been constructed, and a less mileage included in each of the other bond issues. The State Highway Commission, however, has endeavored to do the best it can for these highways in the way of maintenance and has demonstrated in a number of cases, especially on interstate connections, that excellent road service can be furnished by the constant and systematic upkeep given by their trained maintenance organizations, even on old county roads previously regarded as very poor. Their modern equipment keeps the road smooth, while the width is gradually increased and the sharp turns cut off. Gravel, fine crushed sand or selected local material is applied in the worst places and travel is kept moving on a smooth, comfortable road. This has been done at a comparatively small cost per mile per year. The Advisory Committee recommended that maintenance be extended by law to all unconstructed state highways open to travel, since many years will elapse before the construction of all the state highways and the best possible road service should be furnished in the interim.

RECONSTRUCTION

Reconstruction was considered vital, first, because the lightly built roads must be protected to preserve the original investment, and second, to make it possible to maintain them in a serviceable condition.

The average cost of reconstruction contracts in 1924 was $23,124 per mile. This high cost was due to the fact that the condition of the roads was often such as to require the building of practically a new road to standards far above those of the original construction. During 1924 the highway department spent for reconstruction more than $5,000,000 and this was much less than the amount actually needed.

The committee was especially impressed with the requirements of maintenance and reconstruction and recommended that the existing revenues for these purposes be increased rather than reduced.

CONSTRUCTION DETAILS

The committee recommended "that no highway should be improved in excess of its earning capacity, and that the program for state highway development should contemplate stage construction."

It was the belief of the engineers on the committee that twenty feet was the least width that should be used in pavement construction. Eighteen feet might be permissible, but the cost of the additional two feet could be offset by the saving in maintenance cost on shoulders and on the edges of the pavement itself. A twenty foot pavement can accommodate efficiently at least 6,000 vehicles a day,

and by slightly increasing the danger in passing, can take care of 10,000 vehicles.

Twenty feet should certainly be the minimum width of graded roadway on mountain roads where sharp turns are frequent and high speed is sometimes indulged in, this being the least width which provides any factor of safety.

Turnouts and parking places should be provided at frequent intervals that will permit vehicles to park clear of the pavement for making repairs or other purposes. To construct this width on much of the heavy mountain grading, and in addition provide adequately for drainage, requires heavy grading quantities. The committee did not consider it feasible or economically sound to build the original construction on mountain roads to a width of less than twenty feet with the expectation that funds will be available in the future for widening. It is never possible, without lack of economy in the original construction, to widen a narrow mountain highway merely by making parallel, additional excavation, but introduction of some new alignment is always necessary.

In flat valley construction a width of thirty feet of grading is none too much, with drainage provisions in addition; this width being required to permit vehicles to park clear of the pavement in conformity with the state law.

Curves should be such as to give at least 300 feet of clear sight distance. A machine traveling thirty miles an hour covers forty-four feet in a second, and two machines approaching each other cover eighty-eight feet. The 300 feet would therefore provide between three and four seconds for each driver to control his car.

BRIDGES AND GRADE CROSSINGS

In the matter of bridge construction, the early practice required counties to build the bridges within their borders. This appears to have been justified then and saved the state more than $6,000,000 for use on pavement construction. However, the type of bridges which is now required for main line highways is beyond the financial capacities of the weaker counties and a serious burden to the stronger ones. The committee therefore recommended that the State assume all future costs of construction of both minor and major structures on the state highway system, accepting, however, such donations as may be offered.

New bridges should be designed to a width greater than the adjacent pavement and even to the full width of the grade in the cases of medium spans. They must be designed to carry the maximum loads of as many trucks as can come at one time upon their surface. The present tendency toward designing six-wheel and eight-wheel trucks will permit an increase in carrying capacity and in total weight, while conforming to the legal requirement for weight per inch width of tire, and such trucks would require heavier bridges than those now used.

Railroad grade crossings have not heretofore received much attention, but the Railroad Commission is alive to the question and frequently has refused to grant permits for opening new grade crossings. The committee recommended a bond issue of $25,000,000 in short-term bonds to be used solely for grade crossing elimination and for bridge construction on the primary system of state highways.

The highway commission has in the past required local communities and counties to furnish all new rights-of-way for state highways. The committee believes that this is an unwarranted burden on the counties and has caused numerous delays to construction work and recommends that the commission should more freely exercise its rights of condemnation and assume all future costs of rights-of-way, although accepting any that may be donated.

FINANCES

In the matter of finances, the committee estimated the cost of completing the present state highway system, together with the additional mileage which it recommends, which totals about 190 miles. This estimate includes about $63,000,000 for grading, right-of-way and structures on the present highway system, $21,000,000 for rock surfacing and $66,000,000 for paving, or a total of $150,000,000; with $6,500,000 for constructing the additional roads. In addition, it estimates about $14,000,000 for major bridges, $14,000,000 for grade separation, 10% for contingencies and 11 1/9% for administration and engineering, giving a total of $223,781,757.

The cost per mile used in this estimate is much higher than that of the original pavement, both because of increase in unit costs and also because of higher standards. The present minimum standard for concrete pavement requires about 2,100 cubic yards of concrete per mile, while the standard in 1912 required only 978 cubic yards. The average price paid for concrete pavement during 1912 to 1916 was $6.35 per cubic yard, while the average paid during 1923-1924 was $13.40. Grading costs increased from 39c. per cubic yard to 75c. during the same interval. The committee estimated that present revenues from automobiles would permit completion of the now uncompleted 3,877 miles in 22 years. Federal aid payments, if continued at the present rate, would shorten the completion time by two years. This continuation however, is uncertain. The committee recommended that the State adopt a plan of financing which will provide for the completion of the present state highway system within not more than 14 years, and to this end, recommended that construction revenues should be provided to the amount of $10,000,000 available for the year 1926 and increasing annually thereafter in proportion to the increase in motor vehicle registration, which increase was estimated to be 50% during the next ten years.

A long discussion is given on the subject of financing, including of course the merits and demerits of the gasoline tax. Under the present law the gross registration and gasoline tax averages $14.75 for all motor vehicles, which is 2½% of the estimated average annual operating cost. The recommendations of the committee for increased tax on motor vehicles would bring this up to 3½%. It is estimated that the owner of a motor vehicle effects a saving of about 20% on improved roads as compared with unimproved, and he should not and would not object to paying 3½% to secure this. The now familiar arguments in favor of gasoline tax are given at length in the report and it suggests that the

additional revenue be raised by increasing the gasoline tax by 1c. and the plate tax, or license, by an average of slightly less than $1.50.

CLASSIFICATION OF HIGHWAYS

The committee recommended a classification of the roads in the present highway system into two general systems, a primary system and a secondary system. The primary system would consist of intercity highways and major interstate connections, known as Class A; and Class B roads consisting of county seat laterals, other important lateral connections and major recreational highways. The secondary system would consist of minor interstate connections, minor recreational highways, and local development highways. It recommended that not less than 75% of the construction funds be devoted annually to the construction of the primary roads until these are completed.

On its tours of the State the committee received requests for the addition of more than 3,000 miles of road to the state system. In the majority of cases these were of little more than local importance, but as already stated, several seemed to merit addition to the system, these totalling about 190 miles in length. The committee was unwilling to recommend further additions, but on the contrary, recommended that no other additions be made to the primary system, and that any additional roads which the Legislature wished to add must be included in the secondary system only, until the present list of the primary system had been constructed.

The use of convict labor on the highways impressed the committee favorably and it recommended that convict camps be increased in number to utilize at least 1,000 prisoners, the savings in prison maintenance expense effected thereby to be paid from the general state funds to the highway funds.

Designing Pavement Reinforcement

Rational formula for determining amount of steel and spacing of joints and the relation between the two, as developed by the Bureau of Public Roads.

There seems to be no uniform practice among engineers as to the amount and placement of steel reinforcement in pavements, or the spacing of transverse joints; and there is a question whether many designers follow or know any rational method of deciding such questions. Based on investigations made by the Bureau of Public Roads, that Bureau has developed a rational method which is fully described by A. T. Goldbeck, Chief of the Division of Tests, in the August issue of the Bureau's official journal.

In brief, the discussion starts with the statement that all contraction cracks are caused by the friction of the concrete on the subgrade as it endeavors to drag itself over it in contracting; or in the case of checking, by the resistance of the lower parts of the concrete to the contracting of the surface skin as it dries out.

As a concrete pavement dries after being laid, it contracts if it can; if it cannot contract, it is subject to internal stress. A given slab would, if there were no friction, draw in each end toward the middle as it dries out. Up to a certain distance from each end the slab may actually be pulled over the subgrade. If the pull exerted by the concrete is not sufficient to overcome the friction, a stress is set up in the concrete. The stress at any point is in proportion to the distance from that point to the end of the slab.

When the stress at any point exceeds the tensile strength of the concrete, a crack occurs at that point. This crack forms a new free end and the concrete on each side of it is drawn toward the centers of new slabs so created, thus widening the crack.

If there is reinforcement in the concrete, this adds its strength to that of the concrete in resisting the stress and thus increases slightly the distance between the free end and the first crack in the concrete. When this crack forms, the steel does not break, but remains under stress and prevents the crack from opening. It therefore keeps the concrete adjacent to the crack in a state of stress, and secondary cracks may therefore be formed as a result of bending stresses induced by the passage of vehicles; also a second crack will occur at a less distance from the first than that was from the end of the slab. The stress in the steel increases as it passes through the second slab and continues to increase through successive slabs, until finally it exceeds the strength of the steel and the reinforcement breaks and an open crack is formed.

Contracting of the pavement, as described above, does not take place until after the curing period has terminated. Curing, by keeping the concrete moist, prevents it from shrinking until it has attained more or less strength. In fact, the daily wetting actually causes an expansion which seems to be about 0.01% of the length of the pavement, and as long as the wetting continues, a compressive stress remains, and this must be counterbalanced by a certain reduction in length before any tension stress begins.

When wetting ceases and the pavement begins to dry out, contraction begins. The contraction measured under laboratory conditions has been found to be as much as 0.05% of the length, or as much as would be caused by a change in temperature of 100 degrees fahrenheit. This contraction takes place during a period of at least three months under rapid drying conditions in the laboratory, but this period would undoubtedly be longer in an actual road. As the strength of concrete continues to increase for a year or more, this contracting takes place at the time when the concrete is comparatively weak. Tests of tensile strength of concrete vary widely, but the Bureau gives as approximate average values: 100 pounds per square

inch at 7 days, 194 pounds at 15 days, 250 pounds at 28 days and 400 pounds at 90 days.

The principal methods employed to prevent shrinkage cracks are the use of joints and of steel reinforcement. If joints alone are used, the space between them must be slightly shorter than that at which the pavement would naturally crack. When steel is used, the joints may be spaced at such distances as will prevent the rupture of the steel at open cracks, as described above.

In designing slabs to meet the former condition, the Bureau uses the equation:

$$f\frac{L}{2}WB = 12\,BtS + a\frac{E_s}{E_c}S \quad \ldots\ldots\ldots\ldots (1)$$

in which—

L=Spacing of transverse joints in feet.
B=Width of pavement in feet.
S=Allowable tension in concrete in pounds per square inch.
f=Coefficient of subgrade friction.
W=Weight of concrete in pounds per square foot.
t=Thickness of pavement in inches.
E_s=Modulus of elasticity of steel.
E_c=Modulus of elasticity of concrete.

In a solution of this equation, the writer has used values as follows:

S=30 pounds per square inch.
$\frac{E_s}{E_c}$=10.
f=2.0.
W=75 pounds.
t=6 inches.
B=18 feet.

It is assumed that at this time the concrete has a tensile strength of between 120 and 190 pounds, and a factor of safety of 4 gives a safe value of 30 pounds per square inch.

To calculate the spacing where steel reinforcement is used, we have the equation:

$$f\frac{L}{2}WB = a\,S_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

in which f, L, W, B, and a represent the same factors as in equation 1, and

S_1=Allowable tension in steel in pounds per square inch.

The value of S_1 is assumed to be 25,000 pounds per square inch.

Solving these two equations for plain concrete and for concrete reinforced with four, eight and twelve ¾ inch round bars, gives the following results:

Spacing of Transverse Joints to Prevent (1) All Intermediate Cracking, and (2) Intermediate Wide Cracks

Amount of longitudinal steel	(1) For no intermediate cracks Feet	(2) For no wide intermediate cracks Feet
Plain concrete	28.8	28.8
Four ¾-inch round bars (a=1.76 square inches)	29.2	32.6
Eight ¾-inch round bars (a=3.52 square inches)	29.6	65.2
Twelve ¾-inch round bars (a=5.28 square inches)	30.0	97.8

It appears from equation[1] that the smoother the subgrade and therefore the less the friction between it and the concrete, the longer may be the slabs. This friction is the most uncertain of the factors involved in the calculations. Further tests are necessary to give a working knowledge of the coefficient of friction of different kinds of subgrades.

The discussion and equation involving the use of reinforcement assumes that this terminates at each contraction joint. There is then no dowel action exerted by reinforcement across the joint. A substitute for this is desirable to keep the pavement on the two sides of the joint at the same elevation, and four methods of effecting this are proposed by the Bureau. One of these, where rod reinforcement is used, is to extend the steel from each slab a distance of eighteen inches into the adjacent slab, the ends of the steel so extended being painted with a hot asphaltic material so that the concrete will not adhere to it. Where contraction joints, as distinguished from expansion joints, are provided, the same method may be employed, but instead of carrying the joint entirely through the pavement, a thin steel plate may be set on edge extending about 2″ from the subgrade into the bottom of the concrete, thus forming a localizer of a cleavage plane. When shrinkage necessitates a crack in this vicinity it will form over the plate in a straight line. The same object may be accomplished by cutting a groove a few inches deep from the surface down, at the proper stage of hardening. If mesh reinforcement is used, asphalted dowels would be used at the joints, extending about 18″ into each slab.

Road Builders and the Sesquicentennial

Philadelphia's "Centennial Exhibition" was the first affair of the kind ever held in this country. We were just recovering from the effects of the Civil War and were in a kind of "Where do we go from here?" attitude of mind. It has been said by students of the country's history that the Centennial did more than any other one thing toward directing the country into the highway leading to material prosperity.

Fifty years have passed, and again Philadelphia is to hold an exhibition—the sesquicentennial celebration of the signing of the Declaration of Independence. A communication from the director-general states: In conference with officers of the American Road Builders Association and with other representatives of the good roads movement, there has been developed the thought that this Exposition can do a great deal towards speeding up the road building program of America by giving special attention to a road building exhibit." "It is estimated by the Transportation Committee, representing the various railroads entering Philadelphia, that no less than 50,000,000 persons will pass the turnstiles of the Exposition during the six months period."

As this would include every man, woman and child within five hundred miles of Philadelphia,

and nearly half the total population of the country, we must assume that the fifty million is the number of *admissions* hoped for, or say ten times the number of individuals who will attend. But five million is a goodly percentage of the population and any impression made favorable to good roads, or to your type of good road—asphalt, concrete, brick or other—on that number of people would undoubtedly have an appreciable effect on the future development of road construction.

Experiences with Ditching Machines

Eighteen or twenty-inch machine preferable to larger for water or gas purposes. In Texas new machine paid for itself in six months.

Some experiences and cost data in connection with operating ditching machines were given by F. H. Shaw, engineer for the Houston Gas and Fuel Company of Houston, Texas, in a paper before a recent meeting of the Southwestern Public Service Association. He first called attention to the wide variation in forms of records and method of stating the cost of machine ditching as used by different owners and manufacturers. If reliable data are to be obtained, he believes that some simple method of records should be adopted generally which will enable prospective purchasers to select the size and type of machine most suitable to their needs.

For the general excavation work of a gas or water system, a machine that will cut a trench 18 to 20 inches wide and from 3 to 5 feet deep is preferable for small mains and services. Excavation for larger mains may be contracted or done by a rented machine.

In presenting cost figures Mr. Shaw assumed them to be applicable to the use of the small trenching machine in a climate similar to that of Texas where construction work can be carried on during the entire year. The average price of such a machine delivered and set up ready to operate seems to be about $5,000. The life of the machine is an open question but he believed that five years was a fair period for calculating depreciation charges, giving these at $1,000 a year. Some of the other figures which he used were: Life in miles, 60, or an average of 12 miles a year. Possible working days in a year, 250. Daily run (average for 17 machines) 550 feet. Yearly run (average for 7 machines) 58,763 feet. Figuring 12 miles of work done a year and the above average per day gives 115 actual working days out of the 250 possible working days, or 46% of the time. Dividing the cost by the life in feet gives a depreciation of 1.578c. per foot. Allowing 8% on the investment and reducing the value of the machine $1,000 each year, the annual interest charge would average $240 or 0.378c. per foot. This gives a charge for interest and depreciation of 1.956c. per foot.

Averaging costs from various sources, Mr. Shaw gives the following costs of operation: Operator, helper, gas and oil, 2.284c. per foot; repairs 0.486c. per foot; giving a total cost of 4.726c. per foot.

A fair average for trench excavation by hand in Houston is 15 feet in ten hours, or 20c. a foot with labor at $3.00 a day. On the basis of 63,360 feet of excavation in a year, the total cost for hand excavation would be $12,672 and for machine excavation $2,997, showing a saving in one year of $9,675.

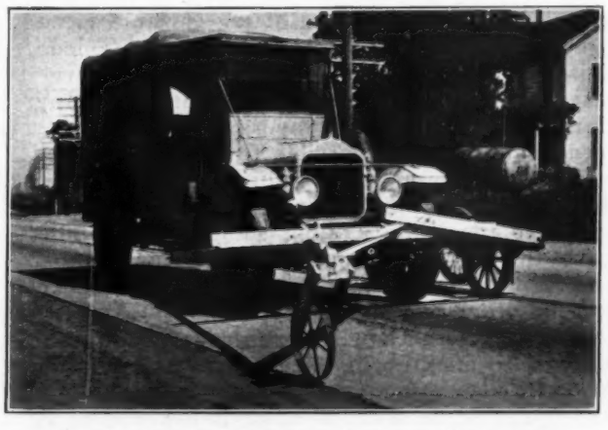
Figuring another way, if we assume the saving of machine work over hand work to be 15c a foot, a machine costing $5,000 would pay for itself in excavating 6.3 miles of trench. Cost data compiled by George Waverly, superintendent of the Houston Gas and Fuel Company, show that a new trenching machine paid for itself in the first six months of operation during which it dug 38,524 feet of trench.

Some figures of actual experience were given by Mr. Shaw. One machine averaged 2,550 feet per ten-hour day digging an 18 x 42-inch trench in sandy clay for gas mains, with a maximum of 3,500 feet in ten hours laying 4-inch pipe with cement joints. Another machine averaged 1,000 feet per ten-hour day for one week digging a 24 x 60-inch trench for a 12-inch main, and 1,080 feet of mains with lead joints were laid in ten hours, the joints being caulked by compressed air supplied by a portable compressor. A third machine has dug at the rate of 100 feet per hour in hard ground, the trench being 18 x 60-inches. A fourth machine has excavated a 24 x 60-inch trench at the rate of 1,000 feet per day.

A small trenching machine was used for excavating a circular foundation trench for a 1,000,000-foot gas holder 130 feet in diameter. The machine was run around once excavating an 18-inch trench and delivering the material to wagons. It was then run around again using blocking in the trench already excavated to support one of the caterpillars, and leaving an 18-inch wall between the two trenches, which was afterwards knocked out with air spades.

A California Highway Marker

The increasing use of a painted stripe down the middle of a road, especially at curves and other danger points, has led to the invention of a number of contrivances for rapidly painting



FRONT VIEW OF TRAFFIC STRIP MARKING OUTFIT.

these lines at reasonable cost. The California Highway Department has recently been trying out one invented by Maintenance Foreman Bicksler of Division 10, which is shown in the accompanying illustration. This is an attachment for a motor truck which consists of two units, one for painting the line and the other for distributing sawdust over the fresh paint to prevent its being smeared over the pavement by traffic.

The marking machine is attached to one side of the truck in front and the sawdust distributor is immediately behind it at the rear of the truck. The marker may be adjusted to mark any width of line desired. Attached to the other side of the truck is an outrigger carrying at its outer end a small wheel so placed as to be easily seen by the truck operator, who guides the truck so as to keep the wheel running along the outside edge of the pavement. The length of the outrigger can be adjusted so as to keep the line at any desired uniform distance from the edge of the pavement.

By attaching this contrivance to a truck it is possible to paint the line more quickly than could be done by a hand-drawn apparatus.

Sewage Pumping in Toledo

Description of plant and details of operation

Toledo, Ohio, has a sewage pumping station operated in connection with its intercepting sewer systems. During 1924 it was used only for the Ten Mile Creek branch, the West Side and Swan Creek interceptors not having been completed. The amount pumped consequently was far below the capacity of the pumping plant.

The plant consists of five motor-driven single-stage centrifugal pumps, four with a capacity of 36,000,000 gallons each in 24 hours and one with a capacity of 24,000,000 gallons. The last and one of the other three are of the variable speed type. The power contract with the Toledo Edison Company provides for a demand charge based on the largest current consumption in any 15 minute period, and by operating the variable speed pumps it was possible to keep the power cost at a minimum except during August, when it was necessary to operate one of the constant speed pumps while making some repairs. This gave the average demand charge for August and September of $389.27 as compared to $226.59 for the other ten months.

Because of the small amount of sewage, it is allowed to back up in the main to an elevation of 85 ft. city datum, when the pumps are started and operated until the sewage is lowered to 72 ft. Pumping is required once and sometimes twice in 24 hours.

During the year the pumps were operated a total of 3712 hours and 15 minutes or an average of 10 hours 8 minutes a day. A total of 3,029,900,000 gallons of sewage was pumped, or an average of 8,278,000 gallons per day, 8,790 gallons being pumped per kilowatt. The largest pumpage was during April when 324,290,000 gallons was pumped and the smallest during November when 163,010,000 was pumped. The maximum daily pumpage was 19,120,000 and the minimum was 760,000.

From the screens, suction well and skimming tank there was removed about 3000 cubic feet of refuse, mostly rags, paper, mash, and leaves, or about 1.02 cubic feet to each million gallons of sewage pumped. This material was buried on the pumping grounds as there was no other means of disposing of it. This was reported by the chief engineer to be expensive, as extra help was required for digging holes for this purpose and the work was disagreeable and unsanitary. Moreover, the ground available was limited. He recommended that an incinerator or other means of disposing of the refuse be installed as soon as possible; also that the grounds surrounding the pumping station be graded and beautified by planting trees and shrubbery.

Salaries of Municipal Employes

The Internal Revenue Bureau has ruled that salaries paid to employes of municipal water works, lighting plants and street railroads are taxable. Moreover, although employes had previously been notified by Bureau representatives that their salaries were not taxable and accordingly did not file returns, the ruling is made to apply to salaries back to 1918, including penalties for failing to file income tax returns.

The matter has been taken up by the American, the New England, Southwestern, and Southeastern Water Works Associations and the Municipal Lighting Association of Massachusetts, all of which have appointed committees to endeavor to secure relief.

These have formed a joint committee which is requesting that all water works' employes, and other interested, write to their senators and congressmen asking them to secure some action by Congress which will straighten out this matter and at least remove the unjust retroactive and penalization features. Relief is asked on the ground that such features are unjust in view of the opinions formerly rendered by Bureau representatives that such salaries were not taxable; also that it is an unjust discrimination between different classes of Municipal employes, for since all such salaries had been considered tax exempt, no differential has been made in fixing water works employes' salaries as compared with those in other departments. For example, employes in the engineering department transferred to a similar grade in the water department would receive a smaller net income due to the income tax imposed in the latter department.

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Keeping Winter Traffic Moving

The snow scenes in this issue may seem somewhat unseasonable, but it is quite possible that twelve to fifteen weeks may find snow falling in such quantities as to demand the attention of highway authorities. And that is none too long a period of time to devote to preparing to meet the snow problem, especially to the acquiring of equipment.

This is our reason for devoting considerable space in this issue to the subject. Officials of state, county, city and town upon whom devolve the duty of keeping the highways open, should, if they have not already done so, decide upon the equipment that they will need for next winter and order it at once. The time remaining is just about that which should be allowed for filling an order for machinery of this kind, getting it through by freight, and tuning it up for prompt, effective action.

This, of course, does not apply to the southern states; but snow handling machinery is used further south than many realize. For example, winter before last the state of Missouri spent $38,000 in snow removal and Virginia used 260 snow plows for that purpose. On the other hand, in parts of some of the extreme northern states the drifts are so deep and the cost of clearing roads through them would be so excessive that it is not attempted and traffic changes to sleighs.

Prevention of drifts by the use of snow fences, hedges, elimination of cuts in road location and other devices is deserving of more attention than has been given it, although several of the states have begun serious work along this line.

Altogether, highway officials will find much of interest and value in the several articles in this issue telling of the experiences of others in meeting this problem of rapidly increasing importance.

More Work with Less Labor

According to statistics compiled by the Associated General Contractors of America, more construction work was carried on in each of the months of May, June and July than in any month in the previous history of the country. Awards for concrete streets, alleys and roads for the first half of 1925 exceeded by twenty per cent the corresponding figure for last year. But the amount of labor in the county is little if any greater than it was last year. Owing to the restriction of emigration, there appears to have been a net loss instead of a gain in foreign labor, and of the increase in population due to the excess of births over deaths in the United States a very small part is added to the common labor class.

Moreover, costs have not risen; in fact, paving prices in some sections were lower in August than for many months past. And this in spite of the fact that wages have been maintained and even increased.

We believe that the answer is undoubtedly—more mechanical substitutes for labor. Those who have looked over our descriptions of "New Appliances" month by month can not fail to have been impressed with the continuous development of new improvements to labor-saving equipment to facilitate handling earth, mixing

and placing concrete, and performing other features of construction work.

Much of this machinery runs into big money, and this must be returned to the contractor during a life of three to ten years, the interest and depreciation being met out of payment for the work done by the machine. The greater the amount of work done per year the less the cents per unit that must be charged against these accounts. There is no "time and a half for overtime" with a machine, and two or even three shifts a day are found to pay on some work. Also longer working seasons will pay, even thought some items of cost are increased by freezing weather.

Should the amount of work per year fall off materially, unit prices must be increased to meet the interest and sinking fund charges—preceded perhaps by a temporary fall in prices while competition eliminates the weaker contractors. It would seem to be to the advantage of all concerned, therefore, to maintain public work construction at its present volume so as to profit by the costs which such volume makes possible—costs which are low compared to wages and which may fall still lower if the amount of work in prospect warrants the development of and investment in still more and more efficient labor saving appliances.

Facts vs. Literature

"When 'Omer smote 'is bloomin' lyre"; when a more modern poet attributed to Barbara Frietchie an "old, grey head" when in reality it was neither old nor grey; when yesterday's paper described the demerits of the other party's candidate; and all in between, those who have written to please their readers (or themselves) have refused to allow a little thing like fact to cramp their literary style.

On the other hand, a paper like Public Works, whose aim is to inform, would sacrifice everything else before intentionally misrepresenting the facts, although we by no means underrate the value of such literary virtues as clarity, conciseness and precision in the use of words. Probably few of our readers have any idea of the number of articles submitted for publication (generally by professional writers) which contain misstatements that only an intimate knowledge of the subject treated of enables us to recognize and exclude from our pages.

These remarks were suggested by a recent occurrence. New York City during July experienced three unusually serious breaks in its large water mains. This was commented on in a letter to the New York Times by one who has reached prominence as a writer, newspaper editor and in later years editor of a well-known encyclopedia. Born in Rochester 85 years ago, he stated that that city had never suffered breaks in its water mains, owing to the honesty of an inspector of its pipe (a class mate of the writer whose name he gave) who, resisting cajolery and bribery, and by means of a hydraulic pipe-testing machine which he carried with him to the foundry (presumably under his arm,) tested and broke every pipe that the foundry had cast for the city, finding every one of them only half the required thickness at mid-length.

We called this remarkable statement to the attention of Beekman C. Little, superintendent of the Rochester Water Works, who has written to the New York Times in his customary clear style, disclaiming for Rochester any such immunity from breaks in its mains and stating that, while Rochester had an inspector of the name given—more than fifty years ago—there is no record of any such remarkable pipe-testing occurrence as that described, it is hardly probable it could have occurred, and there would have been no sense in skimping the thickness of the pipe as it was sold by weight.

Mr. Little supplements this statement with a tribute to W. W. Brush, deputy chief engineer of the New York Water Supply, under whose direct supervision the distribution system of that city comes; stating that he is possibly the best equipped man for that particular job to be found, has the respect and confidence of all waterworks managers, and that his ability and integrity are unquestioned. This statement he makes because of an implication in the letter that if present-day inspectors and waterworks officials of New York City were as honest and intelligent as this Rochester inspector, New York would not have suffered these breaks in its mains.

Similar aspersions of engineers and other public works officials are by no means uncommon and we believe in the majority of cases are uncalled for, and it would seem to be the duty of engineers generally to defend the reputation of the profession by refuting such false statements wherever learned of and correcting as far as possible the unjust and unfavorable opinion of public officials which such statements give rise to in the minds of the general public. This Mr. Little did in his letter, giving a clear explanation in popular language of why cast-iron pipes break, especially in the streets of a city like New York, filled with other conduits while heavy trucks and street cars pound on the roadway above. "Is it any wonder" wrote Mr. Little "that occasionally some spot in the more than 1400 miles of water pipes lets go? The marvel is that, even with the utmost vigilance in construction exercised by your competent water bureau officials, there are yet comparatively so few of these calamities."

Mr. Little is defending officials not in his own department or even in his own city, but for the credit of his profession. Also, he realizes that, although the statements made in the letter criticised may seem to waterworks men too foolish to be worthy of notice, they would probably be accepted without question by those not familiar with waterworks matters and that, for the standing of the profession with the public, it is desirable that their falsity be proved by an explanation that is understandable by every one.

A Florida Concrete Pavement

Central mixing plant method found impracticable because of heat. Batch trucks could not travel on sandy subgrade.

What is said to be the most heavily traveled highway in Florida is the road connecting Jacksonville with the beach on the Atlantic Ocean 16 miles away. This road has been paved since 1914, but the pavement was too narrow to carry the traffic, and a boulevard 32½ ft. wide is being constructed for this purpose by Duval county, the alignment being straightened and two railroad grade crossings eliminated and the maximum grade reduced from 5% to 2%.

The new road, called Atlantic Boulevard, will have two 16 ft. concrete driveways separated by a 6-in. strip of bituminous macadam. The slabs are of the Illinois section, 9-in. thick on the outer edges and 6-in. at the center. At the ocean end the pavement is 100 ft. wide for a distance of 800 ft. to provide parking space, this wide section extending to the edge of the water at mean tide and being uniformly 6-in. thick.

The subgrade is sand from 4 to 10 feet thick, part of which can be rolled if thoroughly wet before hand, but the other kind, a yellow sand, is so yielding that planks are necessary for getting a 10-ton roller across it.

It is necessary to maintain traffic on the old road during the construction and the old pavement is left in place wherever possible, while one 16 ft. concrete strip is laid the entire length of the road before the other is started. The work is being done by C. F. Lytle Construction Company of Jacksonville. It was by far the largest concrete pavement job this company had constructed in Florida and it seemed adapted to a central mixing plant such as the company had used in Iowa work. Sidings, bins and sheds were built near the west end of the road and trucks began hauling mixed concrete to a point about five miles distant.

However, trouble was experienced at once, the concrete drying out so rapidly in the middle of the day that proper finishing was impossible, although before 9 o'clock in the morning, or after 4 o'clock in the afternoon the atmospheric and temperature conditions were more favorable and the concrete arrived in workable condition. If the concrete left the plant with the consistency which the contractor had found to be best in Iowa work of this nature, by neither machine nor hand finishing methods was it possible to secure an even surface; while if more water was used in mixing the materials separated in transit. The contractor tried keeping the aggregate saturated with water in the bins and stock piles and a wet canvas cover was spread over the concrete during its trip in the truck, but satisfactory results could not be obtained.

Central mixing was therefore replaced by central proportioning and a new 32 E paver was purchased and 50 trucks were equipped to haul two batches each of proportioned materials. Under this method work has been going forward satisfactorily. Some of the haul is over the old pavement and some over that part of the concrete slab which has been opened to traffic. The trucks do not back-up to the skip as is customary in work of this kind, but drive up beside the mixer, keeping on the pavement, and dump into a specially built box which is swung over the skip by the mixer crane and dumps the materials through bottom doors held in place by chains. This keeps the soft sand subgrade from being cut up by the trucks and eliminates danger of the trucks becoming stalled while backing in or turning.

The pavement is finished by the use of both Lakewood and Ord finishers, the final finish being given by a hose which is dragged over the surface in a long loop, leaving the surface free from the cross marks so often found in a belt-finished pavement.

Plowing Asphalt Pavement

Removing a sheet asphalt surface by means of a plow, as performed in Waterloo, Iowa, is described in a communication received by us from C. C. Hermann, consulting engineer of that city. He states that a contractor using a plow and six horses found that he could remove the concrete at a less cost per square yard than by means of a gang of workmen with picks and shovels. Two men were required on the plow and one man driving the horses. This work was found to be dangerous for both men and horses, as the plow would jump occasionally and run out of the asphalt, and considerable time was required to get the team and plow back and started again.

Last year the Bryant Paving Company of Waterloo used a tractor to draw the plow, as shown in the accompanying photograph. Two men were required on the plow handles and one man on the tractor. This method was found to have many advantages over the use of horses, among the principal of which may be mentioned steadiness of power application. Should the plow jump from its hold on the asphalt, the tractor was easily backed up and a new bite taken. The work was very hard on the horses and an occasional rest was necessary, but this of course was not required by the tractor. It was found also that the cost of the tractor was low as compared with that of horses.

PLOWING UP ASPHALT WITH A TRACTOR.

Electrically Operated Pumps

Discussion of the question, "When Are Electrically Operated Pumps Economical?" Bearing of power charge schedules on size of motor.

A number of useful hints on selection and design of pumping plants of moderate size, say up to 250 h.p. and heads around 150 to 200 feet, are given by F. S. McClintock, chief engineer of the Dravo-Doyle Co. of Pittsburgh, Pa., in a paper before the Indiana Section of the American Water Works Association, entitled "When Are Electrically Operated Pumps Economical?"

He states at the start that no general answer can be given: "Pumping capacities and heads, fuel and electric costs and local operating conditions vary so widely that the only satisfactory way to decide each case is by a careful trial calculation of costs on paper."

In most cases the pump used for electric operation will be the direct connected centrifugal, although triplex or other direct acting motor driven units are useful for small capacities and high heads.

"Ten to fifteen years ago three questions about reliability of electric drive were frequently raised: (1) is the type of unit, that is, motor driven centrifugal, reliable; (2) is the power supply, generally from some public service company, dependable; (3) if I dismantle my plant what assurance have I that the power company will not squeeze me on the rates; that is, is the power price reliable? Ten additional years' experience and innumerable installations have answered the first objection; serious outages on modern power systems are becoming fewer and fewer, especially as the systems are becoming interlocked in so-called giant power circuits; and commission control and published rate schedules have largely dissipated the last objection.

"The electrification question generally comes before the superintendent or owner of a water plant when some elaborate repairs or replacements are involved to an existing steam plant; his pumps are worn out or, more frequently, his boilers are beyond repair. He is then required to give careful thought to what can be done by electrification. On one side must be set past operating costs with steam, which are known, improved by such economies as can be reasonably expected of new apparatus; and he must consider the investment involved for new equipment. As against these are the unknown operating costs with electric power and its investment charges. It is fortunately possible to estimate with considerable accuracy what electric operating power costs will be, if the pumping demand is known or can be predicted. There are practically no accessories required by an electric pumping installation and usually the entire power bill is determined by the main unit. There is no necessity of allowance for coal under banked boilers, steam losses by condensation, steam required by boiler feed pumps and other auxiliaries, and similar items which so complicate an estimate for a steam installation. Usually the only auxiliary involved in an electric station is a priming pump of some sort. Therefore, given some estimate of the pumping demand and a power schedule, a close idea of the monthly power bill, which is by far the largest item of yearly expense, can be obtained.

"For any given conditions of head and capacity, the pump manufacturers will furnish figures of first cost and power consumption. The power required depends on the motor and pump efficiencies and it may be asked what allowance should be made for falling off in efficiency due to wear, in computing expected power bills for future years. The motor efficiency is generally accepted as constant. The pump efficiency losses will vary and may be considerable when handling sandy or muddy water. With the average water works, however, the main unit, where nearly all the power is used, handles clean water only, and in this service the loss in efficiency in a properly designed pump is very slow. I have seen pump wearing rings after four years' service with the tool marks fresh on them; published tests of the large motor pumps at Minneapolis, where careful power and capacity readings were regularly taken, show no measurable loss in efficiency after four years' continuous service averaging about twenty hours per day, and without replacements or repairs to any interior parts of the machine. In some cases power bill estimates are made on the original stated efficiency without any allowance for deterioration on the ground that no greater error is involved than would be found in variations in slip or leakage losses in a steam unit; in any case one or two per cent. allowance should be ample, for when the losses are much greater it generally pays to bring the unit back to its original performance by installation of new wearing rings.

"Two general results of a trial balance may be expected; the first cost of electrical equipment will be far below that of equivalent capacity using any other drive; and the expected monthly electric power bill will be larger than the monthly coal bill. The final judgment must, of course, total these and other factors into a final yearly operating cost for comparison.

"In figuring electric power costs and in the selection of units, if the installation is finally made, I would suggest the consideration of some features of modern power schedules which are important, if best results are to be obtained, especially demand charges and power factor.

"It is better not to install motor units of much larger capacity than necessary. No one wishes to disregard expected growth and increased demand and install units only just large enough for present requirements; but it must be remembered that the power company will charge considerably more for pumping a million gallons in eight hours than for the same amount in twelve hours. Do not, therefore, put in pumps larger than that for which you can reasonably expect use. In the very common case of a small storage capacity and varying seasonal demand, consideration should be given to combinations of various sizes of units to meet varying requirements; for example, a 1, 1½ and 2 m.g.d.

unit instead of three 1½ m.g.d. units. A further very desirable way of providing for future expansion is to buy pumps and motors large enough for expected future conditions, and have the pumps equipped with impellers of smaller capacity and, therefore, smaller horsepower demand for present conditions. Most power companies base their demand charge on the actual k.w. demand as read from a demand meter and not on the motor size, and a lower current rate can be secured until the pumping demand increases to the limit of the smaller impeller, when the unit capacity can be increased to the maximum by the installation of a new impeller at a very reasonable expense.

"Few people appreciate how wide a range is available in this way due to the flexible nature of the centrifugal pump. For instance, out of a given 4-inch single stage pump case, it is possible to develop efficiently any capacity from 300 g.p.m. to about 650 g.p.m. by changing impellers; similarly with an 8-inch pump a range of from 1400 g.p.m. to 2400 g.p.m. is possible. The cost of the pump itself is ordinarily unchanged within this range; therefore, it is possible, without adding to the cost of the pump end of the unit, to install a machine for a present capacity of 2 m.g.d. and an ultimate capacity of 3½ m.g.d. Ordinarily it pays to install at the start a motor of sufficient size for the ultimate capacity, but if desired or if required by the power company, a smaller motor can be installed at first and provision made on the bedplate for ultimate changes.

"As an example of the effect of an oversize unit, an estimate made recently for a small water plant may be of interest. They had a present demand of 850,000 g.p.d. at about 175 feet and wished to consider a 2 m.g.d. or 3 m.g.d. unit, running part time They had reservoir capacity to pump the required amount and close down for the balance of the day. If a 3 m.g.d. unit was installed the daily pumping could be done in 6 2-3 hours and the load would be approximately 100 k.w., or a total of 667 k.w. hours per day. The monthly power would be 20,000 k.w. hours. If a 2 m.g.d unit was installed the unit would run 10 hours per day, the load would be 66.7 k.w., the daily power would be 667 k.w. hours; the monthly power would be 20,000 k.w. hours as before. On account of the smaller demand charge the monthly power bill worked out at $498.50 for the 3 m.g.d. unit and $405.20 for the 2 m.g.d. unit, although the same amount of water was pumped and the k.w. hours per month were identical. This represented a saving of 19 per cent. in favor of the smaller capacity and would have paid for a 2 m.g. impeller for the 3 m.g. unit in about two months.

"This sort of thing can, of course, be carried to extremes, and it is not intended to suggest that a series of impellers be carried for installations as seasonal demand varies, but in cases where it is found that the required pumping is being obtained in less than convenient operating shifts, a very appreciable saving can often be made by pumping at a lower rate. On the other hand the necessity for additional attendance may wipe out the power saving. "Off peak current rates" may make it desirable to pump the daily supply in a few hours, but my own experience has been that it is rarely possible to take advantage of this type of current supply.

"Regarding power factor, it is only recently that any change was desirable from the squirrel cage motor. This type is perfectly satisfactory and was practically standard for motor driven centrifugal pumps. If properly loaded it will give a power factor of 0.89 to 0.95, and even at half load, as might be involved by a small impeller for present conditions, the power factor should not fall below 0.85 to 0.87. Recently the power companies have been offering discounts for improved power factors. These are expressed in various ways, but generally run from 1 to 5 per cent., if the station power factor is kept at unity. Under these circumstances synchronous motors with direct connected exciters frequently repay the higher first cost. This type of motor is, of course, more complicated than the squirrel cage, but the starting apparatus has been much simplified lately until it is practically no more difficult to handle than the squirrel cage motor; in fact for the smaller sizes the same type of starter is used. Synchronous motors have been developed and are regularly built with sufficient starting and pull in torque to start a primed centrifugal pump. It is generally desirable, however, to start with the discharge valve closed bringing the unit to speed before opening the valve to the line. Under these conditions the horsepower and torque involved in starting is reduced to about 40 per cent. of that at full discharge.

"Synchronous motors are not made in small powers for pump speeds. In general, present experience indicates that they rarely are warranted in sizes below 75 to 100 h.p., on account of the disproportionate increase in cost due to the separate exciter. They add from 50 to 100 per cent. to the cost of the motor, as compared to a squirrel cage type, the greater increase applying to the smaller sizes; this corresponds to 15 to 50 per cent. increase in the price of the complete unit. In plants where the installation consists of small powered low service or raw water pumps with larger powered high service units, synchronous motors on the high service can be run at slightly leading power factors to compensate for the smaller squirrel cage motors on the low service, and a station power factor of unity obtained. It is now possible to obtain full automatic starters for these synchronous motors, either push-button or float controlled, and there are practically no conditions to which they cannot be successfully applied where the power discount warrants the expense.

"A point in connection with figuring operating costs, aside from the question of power bills, is the matter of attendance required. Simplicity and lack of constant attendance on a motor driven centrifugal are not always taken advantage of as they might be, and in figuring prospective operating costs consideration should be given to whether labor and attendance charges as involved with steam equipment cannot be materially reduced. Cases could be cited where the pump house is locked up all day, to be visited morning and evening for general inspection, filling of oil wells, etc. The care of the pump is frequently so small an item that it can be combined

with other work about the filter plant or elsewhere. This is often one of the greatest savings.

"Especially where a system has limited storage in standpipe or reservoir, sole dependence cannot be put on a single power line to the station, no matter how many generating stations are tied into the circuit. The question of standby or emergency power sources has been conveniently solved by high speed gasolene engines of the motor boat type direct connected to the centrifugal pumps. This meets the requirements of the Underwriters as an emergency power supply, has no standby power charges, can be run by anyone reasonably familiar with automobiles, requires no warming up, is ready for immediate service and involves no great initial expense. Dual drive units, that is a pump with a motor on one end and an engine on the other with a clutch between the engine and the pump, are most common. A separate gasoline engine driven pump is sometimes desirable, especially when high pressure is required for fire service. Where a number of small motors scattered around a plant all must be kept in operation, it may be preferable to install a single gasoline engine driven generator of sufficient size to run all essential motors instead of attempting alternate drives for such small machines.

"An interesting application of gasolene drive is in its use for avoiding peak loads which would increase the monthly power demand charges. Some account of this may be found in a paper by W. S. Lea in this journal, October, 1924. Occasional use of a separate gasolene driven unit for a few hours prevented their starting a second motor driven machine which would have increased the demand charge for the entire month. In another town they were required to put on a booster pump and raise the pressure for fire service, and this had to be done in case of each alarm regardless of whether any additional water was actually used or not. A single alarm increased their monthly power bill considerably, due solely to the increase in demand charge, until they met these emergencies by starting the gasolene driven unit which left their demand charge unaffected and cost them only the gasolene actually used. Modern engines of this type use from 1-8 to 1-10 of a gallon of gasolene per horsepower hour; it is not necessary to carry a large stored supply, on account of the number of sources available. The engines themselves will cost from $30 to $50 per horsepower.

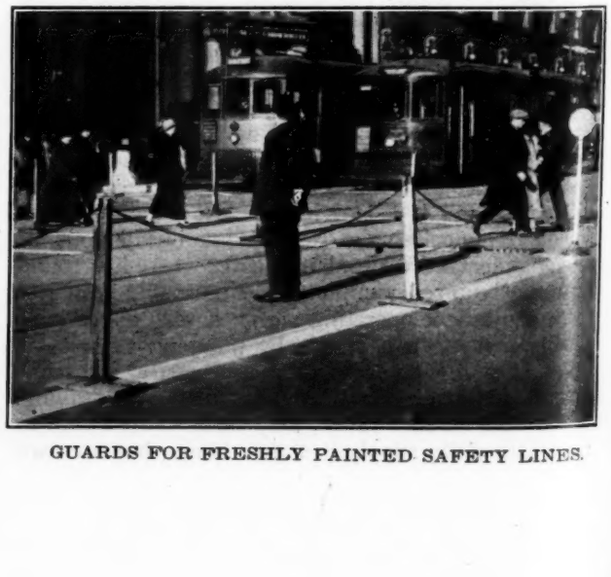
"The motor driven pump is at its greatest disadvantage in cases where the pumpage is direct to the mains without standpipe or reservoir. This condition can actually be met either by using a slip ring motor with about 10 to 15 per cent. speed variation or by constant speed units allowing the pressure to vary slightly with the demand. Centrifugal pumps may be designed with flat characteristics so that the rise in pressure between full capacity and no delivery is only about 10 per cent. The pressure change in the line under varying demands will then not be so serious; but it is very wasteful of power and it will probably be necessary in figuring approximate power costs to take the full pump horsepower regardless of the variation in water demand. Different sizes of units are particularly important here to meet varying demand. No arrangement of motor pumps has been devised which can approach a steam driven unit as regards flexibility in installations of this kind, and the few actual electric plants that I know of have in each case had special circumstances which dictated the type.

"When a city light plant is combined with a pumping plant, it is harder to show a case for motor pumps; it may still pay to use motor pumps, taking current from the town supply, especially for small units, such as raw water umps which are inherently uneconomical in small sizes in steam drives.

"All of this discussion of operating costs has left out of consideration one of the advantages of motor pumps and a factor which on equal or slightly unfavorable cost bases would still sway the decision in favor of motor pumps. Unless you are familiar with motorized plants it is hard to appreciate the simplicity and absence of constant attention involved. Recurrent epidemics of coal shortages and progressive contamination of boiler feed water with the more rapid destruction of boilers have placed heavy worries on the shoulders of small plant operators who must keep continuous service. It is worth something to pass these troubles on to a larger organization such as the central power company, whose business it is to cope with them and who can afford to make elaborate preparations to guard against them. If you add the simplification of the operating labor question, this factor has frequently determined the type when operating costs alone would not have justified a change."

Protecting Traffic Lines

In painting lines on the pavement for marking safety zones and traffic crossing lanes on Market street, the city of San Francisco recently tried out a method of protecting the fresh lines while they were drying without shutting off the traffic. This was done by constructing low frames formed of slats nailed to two thin parallel cleats, these being spaced sufficiently far apart to straddle the painted lines, one cleat resting on the pavement on each side of the line. These frames were made in 4 ft. lengths. Where the lines paralleled street car tracks, they were guarded by temporary uprights supporting ropes which were placed immediately above the lines.



GUARDS FOR FRESHLY PAINTED SAFETY LINES.

Snow Handling on Connecticut Highways

Eighteen hundred miles kept clear with 145 truck plows. Organization and equipment. Plan of operation.

The following information concerning snow work by the Connecticut State Highway Department has been furnished by George E. Hamlin, superintendent of repairs of that department.

In Connecticut, a total of 145 trucks are fitted with snow plows to clear some 1800 miles of highway, this being an average of 13 miles per truck. This average, however, does not in any way represent the mileage of any particular truck, this being governed wholly by the importance of the road and the conditions existing in each locality. On the heavily traveled main thoroughfares between large cities a truck may be scheduled for less than five miles of plowing, while on the less important highways and connecting State Aid roads, a truck may be operated over twenty or more miles.

Each truck is scheduled in accordance with the importance and necessity of traffic. On the main Boston-New York highway in some sections plows are worked in batteries, as in this way mechanical trouble occurring to one truck does not necessarily tie up any particular section of this important highway for any considerable period.

We have found that mobility of equipment is secondary only to personnel. From telephone reports received from the foremen through the district engineer, to the maintenance engineer, information is rapidly developed showing a necessity and permitting the transferring and centering of equipment at any particularly congested location.

During the past three seasons, the cost of snow removal in the State of Connecticut has been as follows:

Year	Total Cost	Average Cost per Mile	Mileage Cleared
1922-1923.....	$175,021.78	$116.07	1500
1923-1924.....	53,800.20	30.35	1800
1924-1925.....	70.453.36	39.75	1800

During the past winter, while the average cost for the State was $39.75 per mile an analysis shows a cost of $15.42 per mile in a district located in the south-eastern part of the state adjoining Long Island Sound, and a cost of $95.32 per mile in the north-western section in which the lower Berkshire Hills furnish more severe weather conditions.

Connecticut has for several years erected snow fences in exposed locations where drifting conditions can be expected. These generally have been found to justify their cost and the mileage has been increased each year. The location should be carefully chosen in accordance with prevailing wind direction, otherwise snow may be banked in the highway by a contrary wind and travel blocked at this point. By the removal of brush along the sides of a highway, the tendency for drift forming can frequently be eliminated. Experimenting along this line will often offer a solution at minimum expense.

Each maintenance engineer is suffering with the complaint of all maintenance engineers—lack of equipment beyond ordinary requirements. A severe snow storm with accompanying wind will develop this complaint almost on the moment into an acute attack requiring immediate operation. This is the danger point. The crisis always passes rapidly. There may remain local conditions to be taken care of but these during the height of the attack may be forgotten. Their solution will follow in natural course when tracks and cars are rolling with the least inconvenience over the length of improved highways in the State.

Discussing the subject of organization, Mr. Hamlin said in a recent paper:

The regular maintenance organization for carrying on snow removal will include:

1—Maintenance engineer and assistants at headquarters.

2—District maintenance engineer in charge of supervision district.

3—Foremen and laborers on each patrol section.

The maintenance engineer is in full charge of the snow removal program and located at headquarters. During the progress of clearing snow, he is necessarily confined wholly to the desk for the receipt of reports and giving of instructions due to changing conditions or severity of storm in any particular locality. To him each district maintenance engineer reports by phone regularly during the storm, giving the location and condition of equipment, the progress of snow removal, and recommendations as to transfer or need of additional equipment. On his desk is a map of the state and as each district engineer reports, the information is transferred graphically to the map so that there exists at all times a chart of progress conditions along the highways. On this map is also recorded additional information reported by the district engineer, including depth of snow and location of drifts. Ordinarily, two operations of a plow will clear the roadway to a sufficient width to permit the passing of traffic. On the map, a single line denotes that a single lane has been opened. On the next passage of the plow an additional line is added to represent the opening of the road to two-way traffic. All roads are opened to this width before attention is paid to the removal of the snow from the shoulders and gutters in order to open up waterways and provide room for the placing of snow in future storms.

The assistant maintenance engineers function directly under the maintenance engineer and report directly to headquarters. Their duties in-

clude inspection of equipment and progress of work during the operation of snow removal and they are in frequent touch by telephone with the main office. Each of these men has a state wide knowledge of conditions and is fully capable of taking full direction charge in emergency, this relieving and supplementing the district maintenance engineer in a snow congested district.

The foremen report by phone as convenient along the road to the district engineer, orders being given that such reports be sent in as frequently as possible. This is necessary, not alone to have information available for the traveling public, but to permit the transferring of any particular organization unit, under necessity, to a point where conditions require immediate attention.

A chart in the main office also carries the locations of each of the snow removal units, these being represented by buttons inscribed with the type and character of such unit. When particularly adverse conditions are reported from a certain district, or a snow removal unit goes out of commission (which will occur where many of such units are in operation,) an examination of the location chart in combination with the progress chart will define the best method of transfer. Orders to the district engineer are telephoned and frequently within a half-hour the relief unit is on its way to the new location. The merchant or property owner with telephone connection along the plow route has proven invaluable in the aid given in getting in touch with the foreman in the shortest time.

The necessary equipment will vary largely with the location and average conditions. In Southern New England, the maintenance trucks are utilized for snow removal and with them the larger portion of the work is done. Each truck of two or more tons capacity is fitted with a push plow with 10 feet blade in charge of the foreman regularly operating such truck, and is assigned to the section which is ordinarily patrolled and maintained.

The trucks usually start operating when the snow has reached the depth of 2 to 3 inches and they are continuously employed until the roads are cleared, this time, in some cases, extending over a period of 36 or more hours. The Trunk Line roads come first in the program, these being followed by the State Aid or secondary roads.

Each truck carries from two to six laborers, depending upon the severity of the storm, in case shoveling is necessary at some particular location. In hilly sections where more snow can be anticipated, tractors fitted with V-type plows are utilized in addition to the truck equipment. These tractors must be designed for mobile use so that they may be transferred to the location of the greatest depth of snow during any paricular storm.

Plow equipment should be located for convenience of operation and so that no time is lost by necessity of distance of travel. Average snow conditions will enter largely into this location.

Familiarity with the section to be kept open is one of the greatest assets in snow removal. During a blinding snow storm with the temperature near the zero mark, it may be difficult to even locate the highway. The foreman who is in charge of this district throughout the year will often recognize by topographical features the location of the truck and will be enabled to minimize delays due to this cause.

It is desirable to stock each district engineer with one or more additional plows and a supply of parts are kept in stock to be transported by light truck on telephone notification. Where possible, it is also advantageous to keep in reserve one or two trucks in each district to replace deficient equipment. A small reserve of men for emergency use is planned by the foreman.

Handling Snow on Illinois Roads

Main routes kept cleared by use of light blade graders, assisted by caterpillar tractors for heavy drifts.

By Frank T. Sheets*

Up to the present time, the Illinois Division of Highways has not delved very deeply into the problem of snow removal inasmuch as our main difficulties are confronted in the northern sections of the State and have been met with emergency equipment. Our experience therefore has been confined largely to keeping our through routes cleared so that the main traffic may be kept moving and in this we have been quite successful.

During the winter months, each of our maintenance patrolmen is furnished a light blade grader and a motor truck and instructed to start using this equipment as soon as about two inches of snow has accumulated on the pavement. By this method, each patrolman is able, except in cases of very heavy snow-falls, to keep his section clear and open to traffic. In instances where extreme drifting does occur, caterpillar tractors equipped with snow-plows designed by our Maintenance Department are used.

Two types of snow-plows have proved satisfactory for our Department. The one most extensively used is constructed of a section of boiler plate about ten feet in length and three feet in width, rigidly braced and attached to the front of a motor truck or to a caterpillar tractor. In some instances we have placed the boiler plate beneath the truck, but this is not the most satisfactory method of attachment. In the second type of equipment, an ordinary blade grader has been successfully substituted for the boiler plate but this type is not to be used

*Chief Highway Engineer, Division of Highways, State of Illinois.

where extreme drifting is to be encountered. These plows are placed at an angle of about 30° with the truck and remove the snow from one-half the pavement at a time. When the entire width of pavement has been cleared, the windrows of snow thus formed on the shoulders are pushed into the side ditches.

The ordinary V-shaped type of snow-plow has also been used but some trouble has been experienced with this equipment due to the snow compacting upon the inner sides of the plow and oftentimes forming a solid mass of ice, almost completely filling the inside angle of the plow.

While we have not as yet had any experience with the rotary snow-plows, this Department has planned to place them, during the coming winter, in our northern District where the snowfall is more frequent and heavier than in other sections of Illinois.

The chief factor in successful snow removal lies in keeping the pavement cleared as the snow falls, thus avoiding in most instances the forming of heavy drifts.

Snow Handling on Albany County Roads

Following experiences of the last two winters, the county will use next winter thirteen miles of snow fence, eight rotary plows, and ten or more push plows.

By William R. Gordon *

The County of Albany, New York, undertook the removal of snow from the highways during the winter of 1923-24. For this purpose the Board of Supervisors voted an appropriation of $50,000. With this sum was purchased four five-ton Holt tractors and one ten-ton Holt. These were equipped with Sargent push plows, the "V" type plow. They were used with fairly good success that winter, which was rather open. We found, however, that when using the push plow for successive snows, it piled the snow so high on the sides of the road that after two or three times there was no place to put it.

During the winter of 1924-25 the county purchased eight miles of snow fence, one additional ten-ton tractor, and equipped the two ten-ton tractors with rotary plows made by the Rotary Snow Plow Company. This plow has no auxillary power but drives off the main shaft of the tractor. It is an all-steel plow with twin sets of fan blades rotating one on each side. We received these plows just at the time of our heaviest snow fall last winter and they were immediately put at work in the most heavily drifted places in the county and kept running night and day until we had opened all the roads. They operate at an average speed of about three miles an hour and will maintain that gait while removing snow four feet deep. When the snow is deeper, it retards the speed in proportion to the depth. We have taken out snow eight feet deep leaving a vertical face and I see no reason why it would not remove still deeper snow. One of the great virtues of the rotary plow is the fact that it does not pile up any snow on the sides of the road; it all is blown and scattered to such an extent there is no appreciable increase of depth on the sides of the road.

During this storm the push plows were unable to do effective work without the help of 20 to 30 shovelers to remove the heavy drifts which they could not buck successfully.

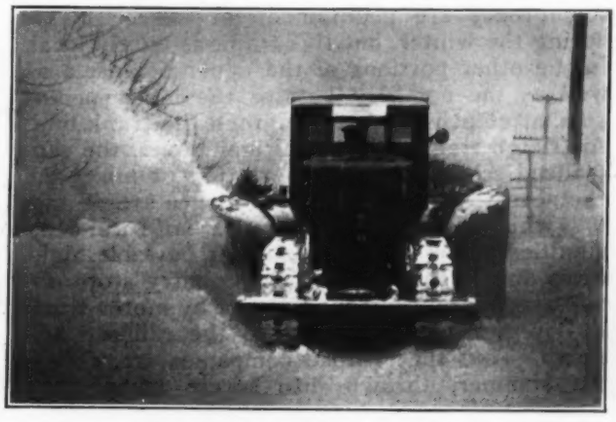
We also put in operation five Sargent heavy-duty push plows attached to at least three-ton trucks. These were used to clean up after the heavy plows and smooth the surface for good traction. They were also used where the snow did not drift too badly, where they operate probably as good as any type of plow. They are particularly successful where they are kept constantly in motion over short stretches of highway. Some of the bus lines were so equipped and the county paid them an hourly rate to keep those roads open over which they operated.

The snow fences were erected in the places of worst drift and they proved to be an immense help, although I believe their use can be overdone. There is a point beyond which the use of too much snow fence would be uneconomical.

The county also purchased a Champion push plow for use on a Linn tractor. This was used as successfully as that type of plow can be used, but successive snow storms and the consequent piling up of the snow on the side of the road greatly impeded later operations.

With this outfit we attempted to remove the snow on 200 miles of State road and about 50 miles of important town roads. This is not enough equipment for that amount of territory. Twenty miles is about all one outfit can take care of. An outfit with us consists of one tractor-driven plow and one truck plow.

During the coming winter the county will probably equip all the tractors with rotary plows and purchase two more ten-ton tractors. With this additional aid and more truck plows and



A ROTARY PLOW ON ALBANY COUNTY ROADS.

*Superintendent of Highways, County of Albany, N. Y.

the addition of about five miles of snow fence I believe we will be able to keep all the roads open without difficulty. The annual expense would probably be about $50,000 to take care of replacements of machinery and the annual expense for labor and upkeep.

Winter Maintenance in Michigan

Selection of roads to be kept open. Prevention of drifting by road location and snow fences. Plows for removing snow.

By B. C. Tiney *

The maintenance of main trunk line highways is no longer confined to the summer season but is carried on with considerable activity throughout the winter in those sections of Michigan where the centers of population and industry warrant the expenditure of money for removal of snow.

The motor vehicle has, within the past few years, become so closely identified with our social and commercial life as to produce a large and constantly increasing demand for highways that are serviceable throughout the year. There has been a marked increase in the manufacture of the closed type of passenger car, which affords comfortable driving in winter weather.

The industrial centers of Michigan are located, largely, in the southern half of the lower peninsula, and in this region the State Highway Department has outlined a system of main trunk lines comprising about 2,600 miles, which was maintained for motor vehicle traffic during the winter of 1924-1925. While this did not include all of the state trunk lines in this area, it was an increase of 34% over the mileage maintained during the winter of 1923-1924. If adequate appropriation for conducting the work is made, it is planned to increase this system to about 3000 miles during the winter of 1925-1926.

In the mining sections of the upper peninsula, some roads are maintained for wheel traffic during the winter, but this traffic is purely local. In the other portions of the upper peninsula as well as the northern half of the lower peninsula, attempt is made to maintain the trunk lines for sleigh traffic. The rural mail route, the centralized school, the transportation of milk, and the necessity for medical attendance are all factors which vitally affect the welfare of rural communities and create a demand for passable highways during the winter. The country store obtains supplies during the summer by motor truck and in the winter, resorts to the railroad and sleigh. Thus the railroad companies are, during the summer, thrown into severe competition with the highway bus and truck lines, and are then compelled to operate during the winter when business is light and the cost of keeping the road-bed clear of snow is heavy. This is obviously ruinous to them financially and many have applied for permission to discontinue branch lines in these sections of the state. This is naturally opposed by local residents as cutting off their only means of winter communication. It is probable that the ultimate solution of this problem will be the abandonment of many branch line railroads and an extension of the snow removal program on highways.

Wherever traffic has been such as to warrant the construction of a pavement, it is logical that this road should be rendered serviceable throughout the year. An average cost of modern paved highways is $30,000 per mile and the interest on this investment at 4% is $100 per month.. If the road is blocked with snow for three or four months each year, we have a fixed charge of several hundred dollars per year which is not giving any value to the public. In view of the fact that the average cost of snow removal in Michigan has been from sixty to eighty dollars per mile per year, and has only in extreme cases exceeded $100 per mile, we may readily appreciate the economic side of winter maintenance.

The average annual snowfall in Michigan varies from thirty inches in the southern part of the state to 130 inches in the Keweenaw Peninsula. The elements of average temperature and prevailing winds also enter into the problem of snow removal. In the southern part of the state, frequent thawing reduces the snow, and, with alternate freezing forms a crust which reduces the tendency to drift. In the colder sections of the northern part of the state, the snow remains in a loose condition for longer periods and is more readily drifted.

PREVENTING DRIFTING

The prevention or control of drifting is the first logical step in the winter maintenance of highways. The capacity of wind to carry snow varies with its velocity, and any obstruction which checks the free sweep of the wind will cause a deposit of snow on its leeward side. Drifting is the most serious on those roads which are at right angles to the prevailing winds, and it is noted that where drifts form each winter in the same location, the causes are usually discernible in fences, trees, brush or weeds in the vicinity. Much can be done to prevent drifting by trimming the low branches of trees, cutting brush and substituting wire fences for the more solid type. Cable guard rail is now being used on all new road construction as being safer to traffic and avoiding the excessive drifting caused by the old type of wooden rail. Drifting may be controlled by erecting wind-breaks at the proper distance from the road. Snow fences have long been employed by the railroads and are now coming into more general use for highways. Various types of portable fence are erected in

*Maintenance engineer, Michigan State Highway Department.

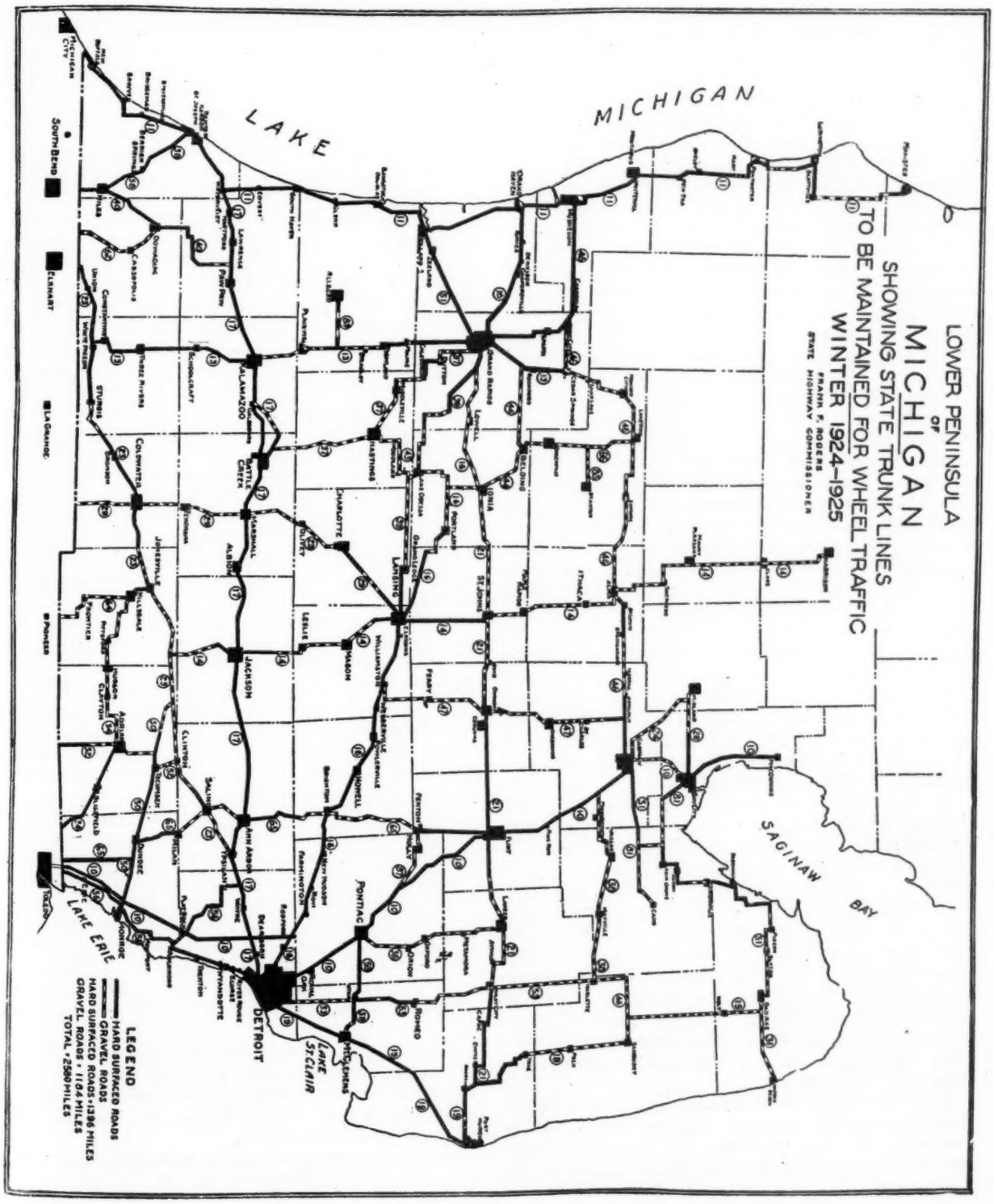
the fall and are proving very effective in forming the drifts between the fence and the road. The purchase of wide right of way and planting of permanent hedges as wind-breaks may be a development of the future.

If the grade of a road is built high enough it may, under some conditions, prevent drifting of snow on the road surface and this element will probably be given more consideration in future road construction.

HANDLING SNOW

In the work of removing snow, a great variety of equipment, designed to meet different conditions, is in use throughout the state. Probably no other class of highway construction and maintenance equipment is being as rapidly developed as the snow-plow, owing to the careful study of its operations by highway officials and manufacturers

The blade-plow, about twenty inches in height,



mounted in front of a motor truck is perhaps the most efficient and popular type in the lighter snow regions of the state. This equipment is capable of removing six inches of snow at a speed of twelve or fifteen miles per hour and will remove as much as a foot of snow at reduced speed. This plow pushes the snow to one side only, and requires a round trip to clear a width of sixteen or eighteen feet. In regions of heavy traffic, a fleet of these plows is put into operation as soon as about two inches of snow has fallen and the work is carried on throughout the storm, until the roads are cleared. The same style of blade, constructed heavier and higher, is used in front of a tractor for snow that is too deep for the truck plow.

The next type of equipment for heavy snow work is the V-shaped plow, about five feet high and twelve feet wide, mounted in front of a 10-ton caterpillar tractor. This plow is very strongly constructed, usually of steel, and has collapsible wings which may be spread to a total width of twenty or twenty-two feet. The caterpillar treads of the tractor are equipped with special non-skid lugs to afford traction on snow or ice, and this type of machine has tremendous power to drive the plow through banks of compacted snow. Only the most rugged equipment will stand the strain of this work.

The rotary snow-plow, which is the highest type in use, has within the past year or two been developed to a point where its performance may be regarded as successful. It is constructed much the same as the heavy V-shaped plow, just described, but is equipped, on each side, with a paddle-wheel which revolves at high speed. As the plow advances, the snow is fed up to these wheels, which pulverize and throw it out to a distance of thirty or forty feet on each side, leaving it spread out in a thin layer. The advantage of the rotary plow over the ordinary V-plow is that it does not leave such high banks of snow along the sides of the roadway, and thereby avoids much drifting on the roadway during the next storm. It puts a great deal of the snow out into the fields instead of piling it up in the side ditches where it will obstruct drainage in the early spring.

In the regions of deep snows, it is not considered practicable to operate the equipment during storms, as these heavy tractors have a speed of only two or three miles per hour and there is a tendency for the cleared portions to drift full again in a short time. By waiting until the storm is finished, the work can be accomplished more effectively, although this has the disadvantage of leaving some portions of the road blocked to traffic for a time. It should be remembered, however, that the railroad companies, even with their long experience in battling with snow, have some periods when their lines are blockaded.

It is the policy of the State Highway Department to remove snow to the full width of the roadway, as this provides for two-way traffic and avoids concentration in one track, with the resultant rutting and severe wear on two narrow strips of the road metal.

While the winter maintenance of highways for motor traffic is a development of only the last few years, we predict that it will increase to such a degree that the public will receive nearly the same service as during the summer months.

Twenty-foot Drifts in Berthoud Pass

The following description of opening up a roadway through drifts six to twenty feet deep in Berthoud Pass, Colorado, by the highway department, is prepared from information furnished to us by Major L. D. Blauvelt, state highway engineer of Colorado.

Since 1922 experiments with a rotary snow plow have been conducted by the Highway Department under the personal direction of Major Blauvelt, which has proved more successful in deep drifts than blades and other snow removal equipment. If left to nature, Berthoud Pass did not become in passable condition before the middle of July and citizens of north-western Colorado were anxious that the pass be cleared as much earlier as possible. This was a powerful incentive to find the most practical equipment for handling deep snow.

As a result of experiments, a specially designed rotary snow plow, adapted from those used on railroads, was put to work on Berthoud Pass on May 17th, 1924. "Through drifts of heavy snow and ice from six to twenty feet deep this machine burrowed its way to the summit of the pass, reaching the Continental Divide on May 26. A roadway from six to eight feet deep and eight feet wide had been cut through the snow from the foot of the pass over the summit on both sides by June 7."

For a distance of two miles on each side of the summit it was necessary to use dynamite to break a crust of ice covering the snow, more than four tons of explosives being used. A snow drift more than 20 feet deep was encountered in the first mile. For six days it snowed—the worst blizzard known to the "oldest residents." A crew of thirteen men was used with the plow, tractor and auxiliary equipment.

"Two trips were made with the plow across the pass. On the second trip, which was started from the western slope, a passageway twelve feet wide was made in the snow. With the snow which melted and that removed later by use of a tractor and heavy grader, the roadway was in such shape by June 10 that cars travelled from Empire to Fraser without skid chains.

"The snow plow and tractor was brought back to the highway shops in Denver on June 13."

A great part of the time the plow was working in zero temperature, in snow, sleet and cold rains. It was estimated that it would have taken a thousand men with shovels to remove the snow in the same time.

Some defects developed in this trial. The chief

(*Continued on page 347*)

Sewage Treatment Plants in the United States

Lists of plants in the several states, with information as to their type, size and other details, furnished to Public Works by the engineers or other officials of the State Boards of Health, concluded from the August issue.

Ohio Municipal Sewage Treatment Plants

City	Population 1920 census	Date installed	Preliminary	Tanks	Filters	Other
Akron	208,435	1916	Bar screen, grit chamber	Two-story	Trickling	Sludge beds and secondary sedimentation
Alliance	21,603	1917[a]	Bar screen, grit chamber	Two-story	Contact & sand	Sludge beds
Amherst	2,485	1911	Bar screen	One-story	Sand	Sludge beds
Andover	921	1912	Bar screen	One-story	Sand	Sludge beds
Ashland	9,249	1902	Grit chamber	One-story	Sand	Sludge beds[b]
Barberton	18,811	1920	Bar screen	Two-story	.....	Sludge beds
Bedford	2,677	1914	Bar screen, grit chamber	Two-story	Contact	Sludge beds
Bellefontaine	9,336	1912	Bar screen	One-story	Contact	Sludge beds
Bexley	1,342	1913	Bar screen	Two-story	Contact	Sludge beds
Brewster	928	1917	Bar screen	Two-story	.....	Sludge beds
Canton	87,091	1916	Bar screen, grit chamber	Two-story	Contact	Sludge beds & lagoon
Celina	4,226	1916	Bar screen	One-story	.....	Sludge beds
Centerburg	775	1918	Bar screen	Two-story	Sand	Sludge beds
Chagrin Falls	2,237	1909	Bar screen	One-story	Contact & sand	
Chardon	1,566	1916	Bar screen	Two-story	Contact & sand	Sludge beds
Cleveland (East)	796,841	1922	Bar screen, grit chamber	.....	.....	Disinfection[c]
Cleveland (West)				Two-story	.....	Disinfection[c]; sludge barged to lake
Clyde	3,099	1898	Grit chamber	.....	Sand	.....
Columbiana	2,114	1914	Bar screen	Two-story	Sand	Sludge beds
Columbus	237,031[d]	1908	Bar screen, grit chamber	Two-story	Trickling	Secondary sedimentation
Delaware	8,756	1903	Bar screen, grit chamber	One-story	Contact	Sludge beds .....
East Palestine	5,750	1917	Bar screen	Two-story	.....	Sludge beds
Eaton	3,210	1910	Bar screen	One-story	Sand	Sludge beds
Fostoria	9,987	1896[e]	Bar screen	Two-story	Sand	Sludge beds
Galion	7,374	1911	Bar screen	One-story	Contact	Sludge bed[b]
Geneva	3,081	1903	Bar screen	One-story	Sand	.....
Granville	1,440	1916	Bar screen	Two-story	Sand	Sludge beds
Hiram	453	1921	Bar screen	Two-story	.....	Sludge beds
Hudson	1,134	1911	Bar screen	One-story	Contact & sand	.....
Jackson	5,842	1911	Bar screen	One-story	Contact	Sludge beds
Jefferson	1,532	1911	Bar screen	One-story	Sand	Sludge beds
Kenmore	12,683[f]	1914	Bar screen	Two-story	Sand	Sludge beds
Kent	7,070	1914	Bar screen	Two-story	Contact	Sludge beds
Lakewood	41,732	1916	Bar screen, grit chamber	Two-story	.....	Sludge beds
Lebanon	3,396	1918	Bar screen	Two-story	.....	Sludge beds
Leroy	241	1921	Bar screen	Two-story	Contact	Sludge beds
Lockland	4,007	1909		One-story	.....	Sludge beds
Lodi	1,240	1915	Bar screen	Two-story	Sand	Sludge beds
London	4,080	1907	Bar screen	One-story	Contract	.....
Louisville	2,008	1911	Bar screen	One-story	Sand	.....
Mansfield	27,824	1902	Bar screen	One-story	Contact	.....
		1918	Bar screen, grit chamber	Two-story	Trickling	Secondary sedimentation, Sludge beds
Mantua	764	1915		One-story	Sand	Sludge beds
Marble Cliff	216	1911	Bar screen	One-story	Contact & Cinder	
Marion	27,891	1905	Bar screen	One-story	Contact & sand	
Marysville	3,635	1915	Bar screen	Two-story	Contact & sand	Sludge beds
Medina	3,430	1906	Bar screen	One-story	Trickling	Secondary sedimentation,
			Bar screen	One-story	Trickling	Secondary sedimentation and sludge beds
Mt. Gilead	1,837	1909	Bar screen	One-story	Sand	Sludge beds
		1917	.....	Two-story	.....	Sludge beds
Mt. Vernon	9,237	1915	Bar screen	Two-story	.....	Sludge beds
New Bremen	1,502	1912	.....	One-story	.....	Disinfection
New Philadelphia	10,718	1915[g]	Bar screen	Two-story	.....	Disinfection
North Canton	1,597	1913	Bar screen[i]	One-story	Sand	Sludge beds
Oberlin	4,236	1894	Bar screen[h]	One-story	Contact & sand	Sludge beds
Orrville	4,107	1908	Grit chamber	One-story	Contact & sand	Sludge beds
Oxford	2,146	1909	Bar screen[i]	One-story	Sand	Sludge beds
Plain City	1,330	1902	Grit chamber	One-story	Trickling	.....
Ravenna	7,219	1908	.....	One-story	Sand	Sludge beds
Rittman	1,803	1916	Bar screen	Two-story	Sand	Sludge beds
Rocky River	1,861	1916	Bar screen	Two-story	.....	Sludge beds and disinfection
Sandusky	22,897	1915[g]	Bar screen, grit chamber	Two-story	.....	Sludge beds and disinfection
Salem	10,305	1913	Bar screen	One-story	Sand[k]	Sludge beds
Sebring	3,541	1912	Bar screen[i]	One-story	Sand	Sludge beds
Shelby	5,578	1900	Bar screen[h]	Two-story	Sand	Secondary sedimentation and sludge beds
Shreve	1,094	1912	Bar screen	One-story	Sand	Sludge beds
St. Marys	5,679	1908	Bar screen	One-story	Sand	Sludge beds
Sylvania	1,222	1910	Bar screen, grit chamber		Sand	Sludge beds
Urbana	7,621	1915	Bar screen	Two-story	Contract	Sludge beds
Vermilion	1,436	1921	Bar screen	Two-story	.....	Sludge beds
Wadsworth	4,742	1908	Bar screen	One-story	Contact[m] & sand	Sludge beds
Westerville	2,480	1902	.....	One-story	Contact & sand[n]	
Wyoming	2,323	1910	Bar screens	One-story	Sand	Sludge beds
Xenia	9,110	1918[p]	Bar screen	Two-story	Sand	Sludge beds

[a] Original installation 1896. [b] One filter used for sludge drying. [c] During bathing season only. [d] Improvements in 1919. [e] Improved in 1915. [f] Not operated since 1919. [g] Not yet in operation. [h] Abandoned in 1915. [i] Screens not in use. [k] Additional sand filtered in 1920. [l] Abandoned in 1917. [m] Contact beds abandoned in 1916. [n] Sand filters abandoned. [p] Original plant in 1903.

Sewage Treatment Plants in Kansas

Information furnished by the State Board of Health. Dated January 1, 1924.

City	Population 1920 Census	Method of Treatment
Alma	789	Imhoff tank and sand filter
Almena	674	Imhoff tank and sand filter
Anthony	2,740	Imhoff tank and contact bed
Ashland	1,147	Imhoff tank and sand filter
Atwood	919	Imhoff tank and contact bed
Augusta	4,219	Imhoff tank and contact bed
Baldwin	1,137	Septic tank and contact bed
Belleville	2,254	Imhoff tank and sand filter
Burlingame	1,330	Imhoff tank and contact bed
Burlington	2,236	Imhoff tank and sprink. filter
Caldwell	2,191	Septic tank
Chanute	10,286	Septic tank
Cherryvale	4,698	Imhoff tank and sprinkling filter
Clyde	1,063	Septic tank
Coffeyville	13,452	Septic tank
Colby	1,114	Imhoff tank and sand filter
Coldwater	1,207	Imhoff tank and sand filter
Columbus	3,155	Septic tank and contact bed
Cottonwood Falls	1,044	Imhoff tank and sprinkling filter
Council Grove	2,857	Imhoff tank and contact bed
Downs	1,508	Septic tank
Eldorado	10,995	Activated sludge
Ellis	1,876	Imhoff tank and contact bed
Elgin	600	Imhoff tank
Emporia	11,273	Imhoff tank and sprink. filter
Erie	1,167	Septic tank
Eureka	2,606	Septic tank
Fort Scott	10,693	Septic tank
Florence	1,317	Imhoff tank
Fredonia	3,954	Septic tank
Garnett	2,329	Septic tank & contact bed
Girard	3,161	Imhoff tank and sand filter
Goodland	2,644	Imhoff tank and sand filter
Great Bend	4,460	Septic tank
Halstead	1,163	Septic tank & contact bed
Hamilton	400	Imhoff tank and sand filter
Harper	1,770	Septic tank & contact bed
Hays	3,165	Septic tank
Herington	4,065	Septic tank
Hiawatha	3,222	Imhoff tank & sand filter
Hoisington	2,395	Septic tank
Holton	2,703	Septic tank & contact bed
Horton	4,009	Septic tank & contact bed
Howard	1,060	Imhoff tank & sprinkling filter
Hoxie	616	Imhoff tank & sand filter
Humboldt	2,525	Septic tank
Hutchinson	23,298	Screens
Independence	11,920	Septic tank & contact bed: Imhoff tank & sprinkling filter
Iola	8,513	Septic tank
Liberal	3,613	Septic tank & sand filter
Lincoln	1,613	Septic tank
Lyndon	732	Septic tank & contact bed
Lyons	2,516	Imhoff tank & sand filter
McPherson	4,595	Sep. tank, Imhoff tank & sand filters; 2 plants
Madison	795	Imhoff tank & sprink. filter
Marion	1,928	Septic tank
Morrill	552	Imhoff tank & sprink. filter
Neodesha	3,943	Imhoff tank & sprink filter
Newton	9,781	Imhoff tank & sprink. filter
Norton	2,186	Septic tank & contact bed
Oakley	768	Imhoff tank & sand filt.
Oberlin	1,247	Imhoff tank & sand filt.
Osage City	2,376	Septic tank & contact bed
Osborne	1,635	Septic tank
Oswego	2,386	Septic tank
Parsons	16,028	Septic tank
Peabody	2,455	Septic tank
Phillipsburg	1,310	Imhoff tank and sand filter
Pittsburg	18,052	Imhoff tank and sprinkling filter
Plainville	1,004	Imhoff tank and sand filter
Potwin	415	Imhoff tank and sand filter
Pratt	5,183	Septic tank
Protection	1,109	Screen and sand filter
Russell	1,700	Imhoff tank and sand filter
Sabetha	2,003	Septic tank and contact bed
St. Francis	733	Septic tank
St. John	1,671	Septic tank
Sedan	1,885	Imhoff tank and sand filter
Scott City	1,112	Imhoff tank and sand filter
Sedgwick	731	Imhoff tank and sand filter
Seneca	1,885	Septic tank and contact bed
Sharon Springs	815	Imhoff tank and sand filter
Smith Center	1,567	Imhoff tank and sand filter
Stafford	1,752	Septic tank and contact bed
Stockton	1,324	Septic tank
Tonganoxie	971	Imhoff tank and sand filter
Valley Falls	1,218	Imhoff tank
Wakeeney	1,003	Imhoff tank and sand filter
Washington	1,406	Septic tank
Wellington	7,048	Septic tank
Yates Center	2,306	Septic tank and contact bed

Municipal and the Largest Institutional Sewage Treatment Plants in Minnesota

Information as of January 1, 1925. Furnished by State Board of Health

Location	Population 1920	Treatment	Final Disposal
Ada	1,411	Septic tank*	Marsh river
Adrian	1,087	Imhoff tank	Kanaranzie river
Annandale	644	Imhoff tank	Pleasant lake
Albany	657	Imhoff tank	Creek
Alexandria	3,388	Septic tank*	Lake Agnes
Anoka Asylum for Insane	2,000	Imhoff tank and sand filter	Rum river
Anoka	4,287	Imhoff tank	Mississippi river
Austin	6,960	Imhoff tank and percolating filter**	Cedar river
Baudette	960	Septic tank	Baudette river
Bemidji	7,086	Septic tank	Mississippi river
Blackduck	788	Imhoff tank*	Ditch to Blackduck lake
Browns Valley	1,058	Imhoff tank	Minnesota river
Bloom. Prairie	1,012	2 Imhoff tanks and sand filter	Ditches
Bovey	1,324	Septic tank	Trout lake
Butterfield	569	Imhoff tank	Creek
Canby	1,754	Septic tank	Lac Qui Parle creek
Chatfield	1,382	Imhoff tank	North fork of Root river
Chisholm	9,039	2 Imhoff tanks* percolating filter and resettling tank	Long Year lake
Claremont	334	Imhoff tank	Zumbro river
Crosby	3,500	Septic tank	Creek outlet Serpent lake
Coleraine	1,300	Septic tank	Trout lake
Deerwood	532	Imhoff tank	Meadow, drains to Serpent lake
Detroit	3,426	Septic tank*	St. Claire lake
Dodge Center	921	Imhoff tank	Zumbro river
Edina	1,833	Imhoff tank pre-filter, sand filter and chlorination	Minnehaha creek
Elbow Lake	867	Septic tank	Lake
Ely	4,902	Imhoff tank	Shagawa lake

Municipal and the Larger Institutional Sewage Treatment Plants in Minnesota

Location	Population 1920	Treatment	Final Disposal
Emmons	223	Imhoff tank	Ditch
Eveleth	7,205	3 Imhoff tanks, percolating filter and re-settling tank	Creek
Fairmont	4,630	Imhoff tank	Creek
Farmington	1,449	Imhoff tank	Vermillion river
Faribault (School for Feeble M...	2,000	Imhoff tank	Straight river
Foley	837	Imhoff tank	Creek
Forest Lake	800	Imhoff tank	Clear lake
Gaylord	783	Imhoff tank	Small lake
Gilbert	3,510	Imhoff tank* & percol. filter	Mine ditch
Glencoe	1,747	Imhoff tank	Buffalo creek
Glen Lake Sana. Hennepin Co.	900	Imhoff tank** and disinfection	Creek
Glenwood	2,187	Septic tank*	Minnewaska lake
Grove City	388	Imhoff tank	Swamp
Graceville	1,022	Imhoff tank	Ditch
Hallock	1,012	Septic tank	South branch of Two Rivers
Hopkins (Minneapolis Threshing Mach. Co.)	300	Imhoff tank	Nine Mile creek
Hopkins	3,055	Imhoff tank	Nine Mile creek
Ironton	1,165	Imhoff tank	Creek to Blackhoof lake
Janesville	1,261	Imhoff tank	Ditch
Kasson	1,150	Imhoff tank*	Creek tributary to North Ford of Zumbro river
Kelliher	514	Imhoff tank	Pond
Kenyon	1,237	Imhoff tank	North Fork, Zumbro river
Kinney	1,200	Imhoff tank	Ditch
Lake Benton	944	Imhoff tank	Ditch to Benton lake
Lake Crystal	1,204	Imhoff tank	Lily lake
Lakefield	1,346	Imhoff tank*	Ditch to Heron lake
Litchfield	2,790	Imhoff tank*	Ditch
McKinley	411	Imhoff tank	Lake
Madison	1,838	Imhoff tank	County ditch
Mabel	549	Imhoff tank	Creek
Morris	2,320	Septic tank	Pomme de Terre river
Morris (Agricultural College)	200	Septic tank	Pomme de Terre river
Maple Lake	677	Imhoff tank	Creek
Mapleton	857	Imhoff tank	County ditch
Mountain Iron	1,546	Imhoff tank	Creek
Mountain Lake	1,309	Imhoff tank	Creek
Nashwauk	2,414	Imhoff tank	Ditch
New Prague	1,540	Imhoff tank	Creek
Pipestone	3,325	Septic tank and sand filter	Creek
Proctor	2,378	Imhoff tank, percolating filter and re-settling tank*	Kingsbury creek
St. Louis County Poor Farm	200	Imhoff tank	Ditch
Sherburne	832	Imhoff tank	Creek
Sleepy Eye	2,449	Imhoff tank*	Sleepy Eye creek
Staples	2,570	Imhoff tank	Hoyden creek
State Sanatorium	350	Imhoff tank	Leech lake
Taconite	621	Imhoff tank	Ditch
Tracy	2,463	Imhoff tank	Ditch to Cottonwood river
Trommald	301	Imhoff tank	Ditch to lake
Virginia	14,022	Imhoff tank with separate sludge digestion and percolating filter	Three Mile lake
Waconia	817	Imhoff tank-disinfection	Clear Water lake
Wadena	2,186	Imhoff tank	Union creek
Walnut Grove	663	Imhoff tank	Ditch
Warren	1,772	Imhoff tank	Snake river
Warroad	1,211	Imhoff tank	Warroad river
Wabasso	459	Imhoff tank	Ditch
Waseca	2,908	Septic tanks (2)**	Clear lake
Wells	1,894	Imhoff tank	Creek
Westbrook	645	Imhoff tank	Ditch
Willmar	5,892	Imhoff tank*	County ditch
Willmar (Insane Hospital)	300	Imhoff tank (2)	Foot lake
Worthington	3,481	Imhoff tank*	County ditch

*Plant inadequate and should be rebuilt or enlarged.
**Plant under construction.

Sewage Treatment Plants in New Mexico

Information as of April 1, 1925. Furnished by Bureau of Public Health

Town	Pop. 1920	% Pop. connected	Treatment: Primary	Treatment: Secondary	Final disposal
*Albuquerque	17,042	85	Separate sludge digestion	Chlorination	Rio Grande
*Artesia	1,115	15	Imhoff tank	None	Small creek
Carlsbad	2,205	100	None	None	Pecos river
Carrizozo	1,405	10	Cess pool	None	None
*Cimarron	500	?	Septic tank	None	Lake
*Clovis	4,804	95	Septic tank	None	Lake
*Deming	3,212	90	Imhoff tank	None	Rio Mimbres
E. Las Vegas	4,304	?	None	None	Gallinas river
*Estancia	578	10	Septic tank	None	Salt Lake
*Gallup	3,902	90	Imhoff tank	None	Rio Puerco
Las Cruces	3,467	90	Septic tank	Nat. sand filters	Drainage ditch
Las Vegas	3,206	?	None	None	Gallinas river
Lordsburg	1,325	?	Septic tank	None	Dry arroyo
Maxwell	400	20	None	None	Canadian river
*Portales	1,154	90	Septic tank	None	Irrigation
Raton	5,544	95	None	None	Eagle creek
*Roswell	7,062	80	Separate sludge digestion	None	N. Spring river
Santa Fe	7,236	40	None	None	Broad irrigation
Silver City	1,100	90	Septic tank	None	Dry arroyo
*Springer	915	?	Septic tank	None	Cimarron river
Tucumcari	3,117	?	None	None	Artificial lake and irrigation
*Dawson	4,045	10	Septic tank	None	Vermejo river
*Gamerco	1,200	20	Septic tank	None	Dry arroyo
*Hanover	200	75	Septic tank	None	Dry arroyo
*Hurley	300	85	Septic tank	None	Dry arroyo
*Tyrone	4,064	60	Septic tank	None	Dry arroyo

*Operating efficiently.

one was that the 10-ton Holt tractor which pushed the plow was not geared down slow enough. The entire plow was built in the shops of the department, mostly from parts of trucks and tractors obtained from the U. S. War Department. The wheel, 6½ feet in diameter, was cast in a local foundry. It was operated by a 90 h. p. Van Black marine motor which had been part of a centrifugal pump equipment used in France during the war The wheel was mounted on a frame of 7-inch steel channels, and supported on wheels from an old Mack truck. Last summer the department obtained from the War Department a 20-ton Holt tractor, which was geared down for use with the plow last winter. Major Blauvelt writes (September 4, 1925): "While the method of mounting our plow is as yet somewhat crude, we expect to perfect same, when we believe we will have a rotary snow plow that will fulfill the requirements necessary to clear our cuts from the deep snow drifts that we experience in the higher altitudes."

Recent Legal Decisions

INVALID RESOLUTION FOR PAVING IMPROVEMENT

The Iowa Supreme Court holds, Carbon Coal Co. v. City of Des Moines, 199 N. W. 170, that a resolution of necessity for a paving improvement without petition of property owners and adopted on vote of three out of five members of the city council and not by a three-fourths vote, as required by Code Supp. 1913, §793, was invalid, voiding the paving assessment thereon.

WHERE HIGHWAY CONTRACTOR HELD "INDEPENDENT" CONTRACTOR

The Nebraska Supreme Court holds, Potter v. Scotts Bluff County, 199 N. W. 507, that one who contracts with a county to furnish tools, appliances and labor, to load, haul and evenly spread 1,500 cubic yards of gravel from designated pits upon a designated highway, for the sum of 49 cents a cubic yard; who may perform the work himself or hire others to do it; who may employ as many men or teams or motor trucks to do the work as he pleases; who has the right to hire and discharge men, fix their wages and hours of labor, and is liable for their compensation; and who has the power to direct when and where the men shall work, is an "independent" contractor within the meaning of the Workmen's Compensation Act, and one of his employees was not entitled to compensation under the act from the county for injuries received while on the job.

ORDINANCE REGULATING DRUG STORES HELD INVALID

The Illinois Supreme Court holds, Lowenthal v. City of Chicago, 313 Ill. 190, 144 N. E. 829, that if a business sought to be regulated has no tendency to injure the public health or public morals or interfere with the general welfare, it is not a subject for the exercise of the police power. The court is of opinion that "the conduct of the drug business, so far as it requires regulation, is covered by state regulation; and inasmuch as the legislative provisions regarding the police power of cities are contained in 100 separate clauses in article 5 of the Cities and Villages Act, in which regulation of drug stores is not provided for, the enumeration given is the exclusion of all other subjects." It was therefore held that an ordinance providing for licensing and regulating the sale of drugs and such articles as are commonly sold in drug stores, preventing such stores being maintained and operated in an unsanitary manner, providing for a penalty for failure to comply with the provisions of the ordinance and providing for an annual license fee of $25, was unenforceable.

SUFFICIENCY OF BARRIER AT ROADSIDE

The New York Court of Appeals holds, Roberts v. Town of Eaton, 238 N. Y. 420, 144 N. E. 667, that a town was not obliged to construct a barrier sufficiently strong to hold a heavy automobile which, in attempting to get out of ruts, slipped on the icy road and went over a declivity. All that was required of it was to erect such a railing, if any, as would be a sufficient protection for travel generally. It was not bound to exercise extraordinary care to guard against unusual accidents.

EXPENSE OF MAINTENANCE OF ROAD

The West Virginia Supreme Court of Appeals holds, State v. State Road Commission of West Virginia, 122 S. E. 527, that a county-district road, taken over by the state road commission as part of the state road system, under chapter 112, Acts 1921 (chapter 43, Code 1923), must thereafter, until legally vacated or discontinued, be maintained by the commission at the expense of the state in so far as funds for the purpose may be available.

RECOVERY OF EXPENSE OF REPAIRING HIGHWAYS FROM WRONGDOERS

In an action by a town for injury to its highways by flooding caused by piers in a river diverting the water during an ice jam, the Vermont Supreme Court held, Town of Sharon v. Awahma Realty Corporation, 123 Atl. 192, that "while towns are not the owners of the highways within their limits, the obligation to keep them in repair gives them such an interest in them as enables them to recover expenditures made necessary by the wrongful act or neglect of an individual or corporation"; and a state statute providing a penalty therefor does not make that the exclusive remedy.

BUILDING PERMITS IN RESIDENTIAL NEIGHBORHOODS

The Pennsylvania Supreme Court holds, Wright v. France, 123 Atl. 586, that a borough could not refuse a permit for a combination store and apartment building merely because it is "entirely out of keeping with the residential character of the community, and thus adversely affects the desirability and value of any residential property in the vicinity," in the absence of anything in the borough ordinance or the laws of the State to justify the refusal for that reason.

NO RECOVERY ALLOWED FOR UNAUTHORIZED EXTRA WORK

The Kansas City Court of Appeals holds, City of Salisbury v. Lynch W. Donald Const. Co., 261 S. W. 356, that if the work was not done according to contract, the contractor for the construction of a well for a city could not recover for any extra work in rebuilding a broken wall even if caused by lack of reinforcing rods in the plans and specifications, where the contract expressly provided that no claim for extra work would be allowed or considered unless previously authorized in writing by the city engineer, and no such authority was given.